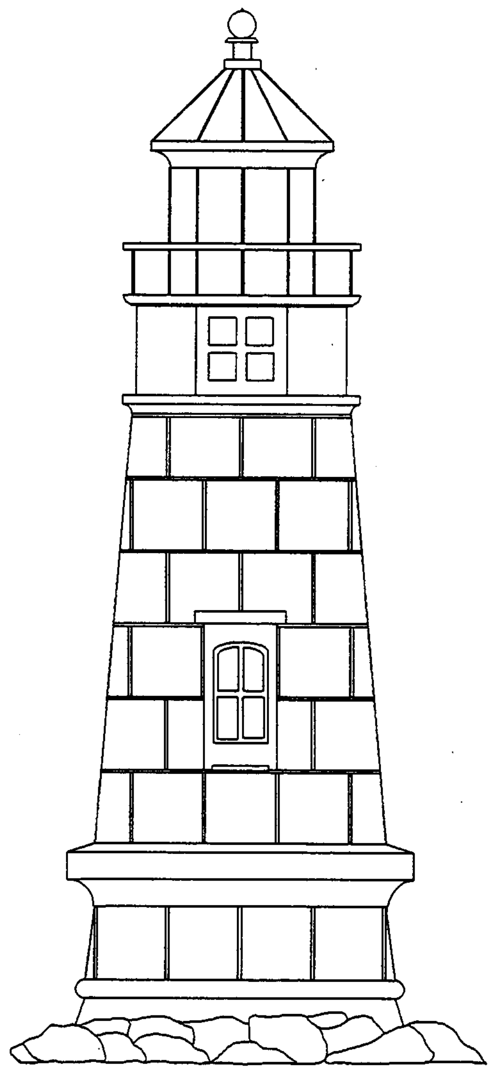
U.S. Department
Of Transportation

United States
Coast Guard

AUTOMATION TECHNICAL GUIDELINES



COMDTINST M16500.8A

U.S. Department of Transportation

United States Coast Guard

Commandant (G-ECV)
United States Coast Guard

2100 Second Street, S.W.
Washington, DC 20593-0001
Phone: (202) 267-1907

COMDTINST M16500.8A

19 JUN 1995

COMMANDANT INSTRUCTION M16500.8A

Subj: AUTOMATION TECHNICAL GUIDELINES

1. PURPOSE. This manual presents technical philosophies and guidelines which should be used in selecting and designing equipment and systems for automated aids to navigation at lighthouses and ranges.

2. ACTION. Area and district commanders and commanders of maintenance and logistics commands shall ensure that the provisions of this instruction are followed.

3. DIRECTIVES AFFECTED. COMDTINST M16500.8 is cancelled.

4. DISCUSSION. Use of a systems engineering approach in the Lighthouse Automation and Modernization Program led to development of a large array of standard lighthouse hardware and configuration selection methods which were used to execute the program. That systems approach is updated in this guideline, and is expanded to include configurations, equipment and methods to be used in standard range light systems and standard solar lighthouses.

5. CHANGES. Recommendations for improvements to this instruction shall be submitted via the chain of command to Commandant (G-ECV).

E. J. BARRETT
Chief, Office of Engineering, Logistics and Development

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AUTOMATION TECHNICAL GUIDELINES

CONTENTS

AUTOMATION TECHNICAL GUIDELINES

CONTENTS (Continued)

FIGURES

TABLES

CHAPTER 1. PROGRAM OVERVIEW AND PROCEDURES

A. Program Goals.

1. The goal of past lighthouse automation and future modernization programs is to reduce operations and maintenance (O&M) costs for lighthouse systems, and to diminish the opportunities for remote or hazardous duty by our people. The O&M costs are contained in transportation, personnel and maintenance equipment/materials.

2. This goal is reachable through a consistent, long-term commitment to the development and use of quality standard equipment design configurations and effective personnel training.

B. Instruction Scope. The manual provides technical guidance for equipment selection, configuration and installation which will be most useful to engineers installing systems of considerable complexity. More guidance on the requirements for modernizing lighthouses may be found in COMDTINST M16500.3, Aids to Navigation Manual - Technical; COMDTINST M10550.25, Electronics Engineering Manual; and COMDTINST M11000.11, Civil Engineering Manual. When guidance pertaining to lighthouse modernization in the above manuals conflicts, direction in this manual applies.

C. Program History.

1. Beginnings. The construction of the first large lighthouses in North America began in the early 1700's. Personnel at these lights, often entire families, cared for the structure and maintained signal operations. Signals were first powered by whale oil, then kerosene, and finally electricity. It is important to note that because of the age of these structures and their importance to the maritime industry, many are now considered to be historically significant properties, worthy of special consideration in their maintenance and upkeep.

2. Automation. With the development of reliable electro-mechanical switching devices and high-endurance diesel engines, removal of personnel and automatic operation became attractive in the early 1960's. Thus began an era of about 25 years during which personnel were removed from lighthouses. Though savings have been achieved as a result of decreased personnel costs, highly reliable operation was not achieved.

3. Present Situation. The bulk of lighthouse system O&M costs now go toward servicing visit transportation and personnel costs. Our next great challenge is to gain

more reliable automated operation, thus creating a diminished need for service visits. Solid-state control systems and natural energy sources will provide this greater reliability, while we continue to properly serve the mariner. The wise implementation of solid-state technology promises to significantly increase lighthouse system reliability and reduce the associated O&M costs. Because of the historical nature of many lighthouse properties, implementation of new technologies must include serious consideration for maintaining the historic nature of the properties.

D. Lighthouse Equipment Configuration Categories.

1. Purpose. Categories help the engineering support manager and the district program manager to discern which equipment configuration will meet the operational needs of the aid to navigation site. The various categories are designed to meet various and distinct levels of operational need. Figure 1-1 merges the operational requirement and engineering support issues into one decision flow diagram. Generally speaking, higher levels of operational need require more signal range (power), higher signal availability (equipment redundancy), and shorter time to restore the signal or advise the mariner of an outage (monitoring).

2. Rationale. Standard equipment configurations encourage better engineering design and operational need decision-making by district program managers. Standardization also allows for economies in personnel training and equipment procurement, and it promotes the effectiveness of maintenance personnel.

3. Configurations. Installation, interconnection, and troubleshooting drawings for these equipment configuration categories are available from Commandant (G-ECV-3) in aperture card format. Chapter 7 discusses installation requirements. All standard equipment is described in COMDTINST M16500.3.

   a. Category I Equipment Configuration. Normally, lights in this category were manned and are a critically important aid to navigation, thus justifying the very substantial cost of installation, operation and maintenance. This equipment suite provides a high intensity light and sound signal and may have a radiobeacon or RACON. Emergency signals and power systems, and remote electronic monitoring make this the most complex equipment suite. (Figure 1-2).

   b. Category II Equipment Configuration. Like Category I, lights in this category were once manned. This equipment suite resembles the Category I suite except that the power equipment is considerably less involved since there is no standby engine-generator. It is intended for sites where commercial electrical power is reliable. (Figure 1-3).

c. Category III Equipment Configuration. This category provides the capability for emergency signals like those above, but without remote electronic monitoring capability. (Figure 1-4).

d. Category IV and V Equipment Configurations. Use these equipment configurations where commercial electrical power is reliable and emergency signals are not required. (Figure 1-5 and 1-6).

e. Category VI Equipment Configuration. Consists of a primary battery and light.

f. Solar Category I Equipment Configuration. Often, lights in this category were once manned and are a critically important aid to navigation, but may now have a diminished signal range requirement. This equipment suite can provide a seacoast light with a nominal range of up to 22 nautical miles, a 2-mile sound signal, and a RACON. Variables of latitude, cloudiness, solar panel area and battery capacity all constrain these system capabilities in some sites. Emergency signals and remote electronic monitoring make this the most complex solar-powered equipment suite. (Figure 1-7).

g. Solar Category II Equipment Configuration. This equipment suite resembles the Category I solar-powered aid to navigation except that it does not have remote electronic monitoring capability. (Figure 1-8).

h. Solar Category III Equipment Configuration. This equipment suite resembles the Category VI aid to navigation, but is solar-powered rather than primary-battery powered. It has no emergency signals, no electronic monitoring, nor any reserve battery capacity. (Figure 1-9).

E. Range Equipment Configuration Categories.

1. General. As increasingly capable range systems become more common, standardizing their signal equipment systems becomes increasingly beneficial. Figure 1-10, Range Category Selection Aid, merges the operational requirement and engineering support issues into one decision flow diagram, to help the engineering support manager and the district program manager make the right selection for a specific range.

2. Configurations. Front and rear signals can be powered independently of each other. Either may be solar or commercial powered, and their function as a range will remain unchanged. Installation, interconnection, and troubleshooting drawings for these equipment configuration categories are available from Commandant (G-ECV-3) in aperture card format. Chapter 7 discusses installation requirements. All standard equipment is described in COMDTINST M16500.3.

   a. Range Category I (Day/Night) Equipment Configuration. Normally, ranges in this category are a critically important aid to navigation, thus justifying the very substantial cost of installation, operation and maintenance. This 120VAC powered equipment suite provides a high intensity daytime light signal, a less intense nighttime signal, and an emergency signal. Switching between day and night signals at front and rear ranges is synchronized by the Range Light Controller (RLC), which can be monitored by a nearby ACMS master if needed. (Figure 1-11).

   b. Range Category II (Nighttime) Equipment Configuration. This category provides a 120 VAC powered signal for nighttime operation with an optional battery-powered emergency signal. (Figure 1-12).

   c. Solar Range Category I (Day/Night) Equipment Configuration. Ranges in this category are a critically important aid to navigation, but generally have shorter channel lengths than Range Category I signals. Variables of latitude, cloudiness, solar panel area and battery capacity all constrain the system capabilities in some sites. This 12VDC powered equipment suite provides a high intensity daytime light signal, a less intense nighttime signal, and an emergency signal. Switching between day and night signals at front and rear ranges is synchronized by the RLC, which can be monitored by a nearby ACMS master if needed. (Figure 1-13).

   d. Solar Range Category II (Nighttime) Equipment Configuration. This equipment suite resembles the Category I Solar Day/Night Range except that it uses a Multi-Array Controller (MAC) instead of a RLC and does not have the remote electronic monitoring capability. (Figure 1-14).

F. Program Planning.

1. Waterways Analysis Management System (WAMS) Studies. Output from WAMS evaluations may be the most significant tool for specifically identifying which lighthouse or

range system category adequately meets the operational need. WAMS evaluations identify waterway criticality and user requirements for ATON systems.

2. Backlog Development. Accurate forecasts of program and standard equipment needs are maintained through Civil Engineering Unit (CEU) and District (oan) project lists or backlogs. These forecasted needs are normally communicated upward by a District Aids to Navigation Operations Request (CG-3213) as a result of a WAMS evaluation, a Shore Station Maintenance Request (SSMR) submission resulting from a biennial civil engineering inspection, or in response to the annual project and equipment planning survey conducted by the Commandant (G-ECV).

3. Project Execution. Engineering support for lighthouse and range systems must be incorporated into the entire engineering support function. We recommend use of experienced Coast Guard in-house engineering talent and industrial capacity. In view of the work's substantially unique character, experience has shown that Architect/ Engineering (A/E) firm and contractor learning curves are often unprofitably long. This will probably become evident in attempts to obtain quality A/E firm designs for lighthouse modernization at a price below the six percent A/E design fee limitation; however, A/E design of modern range structures has proven successful.

4. Engineering Support Units. Maintenance & Logistics Commands (MLC) will need to effectively merge the engineering and design capacity in the Civil Engineering Units (CEU) and MLC Electronic Systems Branches [MLC(tes/tst)] with the support demand from district program managers and the area funds available to execute projects.

G. Project Submission.

1. Required Documentation. Lighthouse and range modernization projects require submission of a project package for headquarters review. The package will consist of an Aids to Navigation Operation Request (CG-3213/3213A), Project Development Submittal (PDS) and ELECTRONALT. Normally, packages should be submitted to headquarters before 1 August each year for subsequent year execution. See Figure 1-15 for the project documentation approval process.

2. Approval Process. CEU's should request the CG-3213/3213A documentation from District (oan), the ELECTRONALT from the MLC(tes), and taking account of environmental and historic preservation requirements, develop the PDS. The CEU shall send the consolidated packages to Commandant (G-NSR) who will conceptually approve the project. After

conceptual approval, Commandant (G-ECV) will do a technical review and schedule shipment of standard equipment for lighthouse installation. Commandant (G-TES) will approve and sign the ELECTRONALT. Final approval of the project will be indicated by a Commandant (G-NSR) endorsement of the CG-3213. This endorsement will address equipment availability and will enclose the ELECTRONALT and the Commandant (G-ECV) approved PDS, with any exceptions noted. Headquarters equipment will be provided upon request (to Commandant (G-ECV) via E-mail or letter) for specific projects after those projects are submitted, approved, and ready for execution. OE-funded lighthouse modernizations are usually executed in the year after project approval. Approved Waterways AC&I-funded projects, typically for new construction of significant range structures, are added to the Waterways AC&I project backlog. When they are within a year of funding, they then enter the CEU design phase in preparation for execution in the following year. Any significant project changes such as scope, cost, structure location, or operational range design, should be resubmitted for approval prior to A/E contract award, or as soon as revealed thereafter.

The following guidance on project documentation applies:

Project Scope	Documentation Required
Any ATON signal or category change	CG-3213 and CG 3213A
Any HQ-Furnished Equipment Category III, Solar II, Range Tower Construction	Same as above plus PDS
Category I and II, Solar I, Range Cat. I, Solar Range Cat. I	Same as above plus ELECTRONALT

3. <u>Aids to Navigation Operation Request (CG-3213 and CG-3213A)</u>. The CG-3213 and CG-3213A shall give a clear indication of existing ATON equipment to remain and new equipment to be installed. The environmental impact of sound signals must be addressed in the CG-3213. Also, any historic property and classical lens disposition issues must be addressed.

4. <u>Project Development Submittal (PDS)</u>. The PDS shall describe the scope of work, cost, and standard equipment needed to modernize or solarize a lighthouse or range system. Its purpose is to ensure that the project conforms to the standard aid configurations and Commandant policy in areas such as environmental compliance and historic preservation.

The PDS cover letter should contain the following items:

a. Operational requirement;
b. Cost estimate;
c. Site plan;
d. Description of the standard system configuration to be employed and standard equipment needed;
e. Floor plan including layout of standard equipment; and
f. Description of project solutions to satisfy environmental and/or historicity problems.

5. <u>ELECTRONALT</u>. The ELECTRONALT shall outline any planned changes to radio aid or electronic monitor and control equipment at the light, in detail. If a radio link is required, frequency authorization shall be requested in accordance with COMDTINST M2000.3., Telecommunications Manual.

CATEGORY SELECTION AID

CATEGORY DEFINITIONS

I. MONITORED AND CONTROLLED, AC-LINE OR ENGINE/GENERATOR SYSTEM WITH ENGINE/GENERATOR BACKUP AND 12VDC EMERGENCY SIGNALS.

II. MONITORED AND CONTROLLED, AC-LINE SYSTEM AND 12VDC-EMERGENCY SIGNALS.

III. AC-LINE AND 12VDC EMERGENCY SIGNALS.

IV. AC-LINE SYSTEM WITHOUT EMERGENCY SIGNALS.

V. AC-RECTIFIED AND STEPPED DOWN 12VDC SYSTEM.

VI. BATTERY POWERED 12VDC SYSTEM.

VII. DAYMARK ONLY.

SOLAR I. REMOTELY MONITORED AND CONTROLLED, 12VDC SOLAR POWERED SYSTEM WITH EMERGENCY SIGNALS.

SOLAR II. UNMONITORED, 12VDC SOLAR POWERED SYSTEM WITH EMERGENCY SIGNALS OPTIONAL.

SOLAR III. UNMONITORED, 12VDC SOLAR POWERED SYSTEM WITHOUT EMERGENCY SIGNALS.

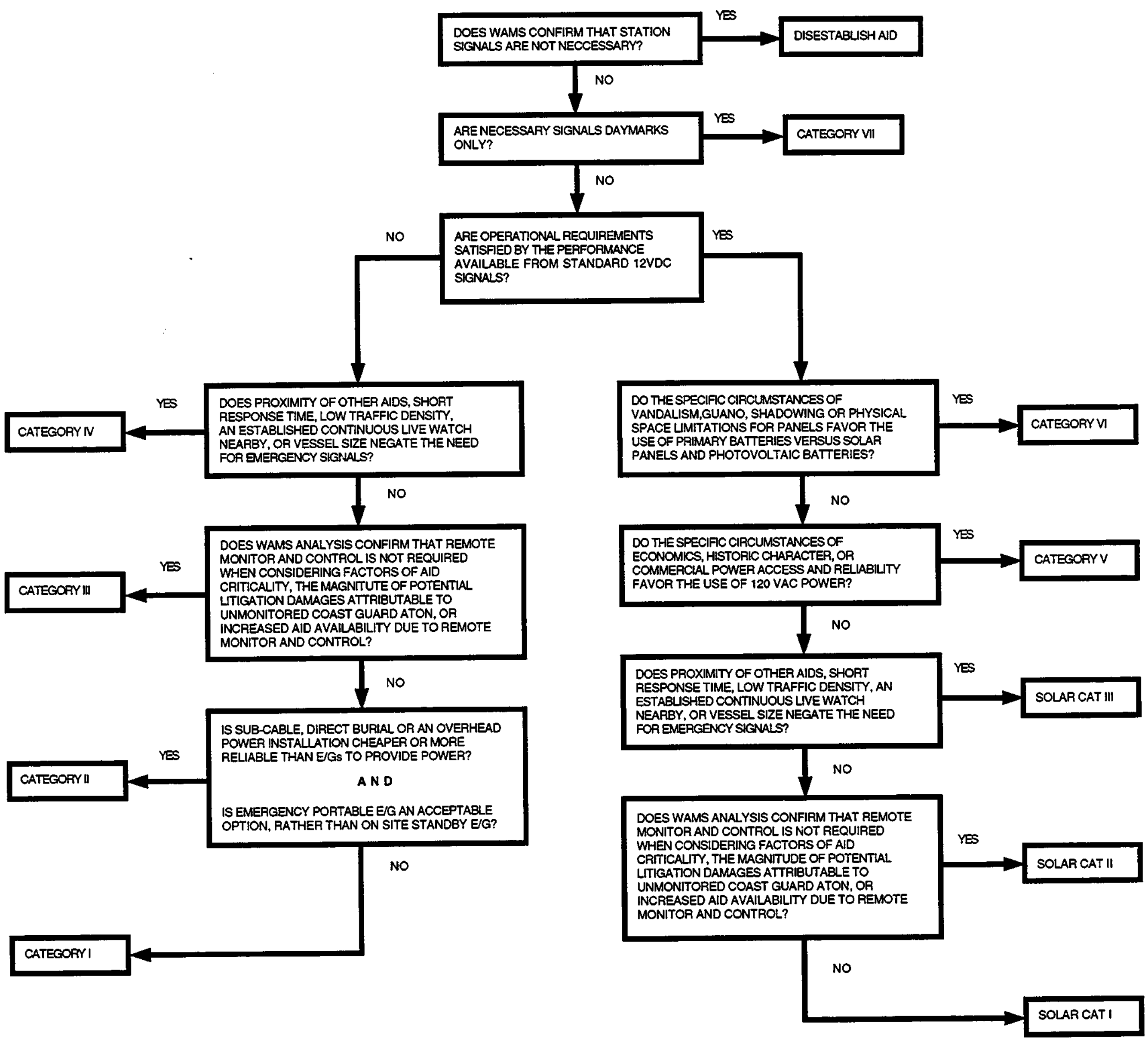


FIGURE 1-1

CATEGORY I

FOG DETECTOR &/OR ACMS CONTROL OF SOUND SIGNAL IS OPTIONAL
SYMBOLS: M = MONITOR, P = POWER, C = CONTROL

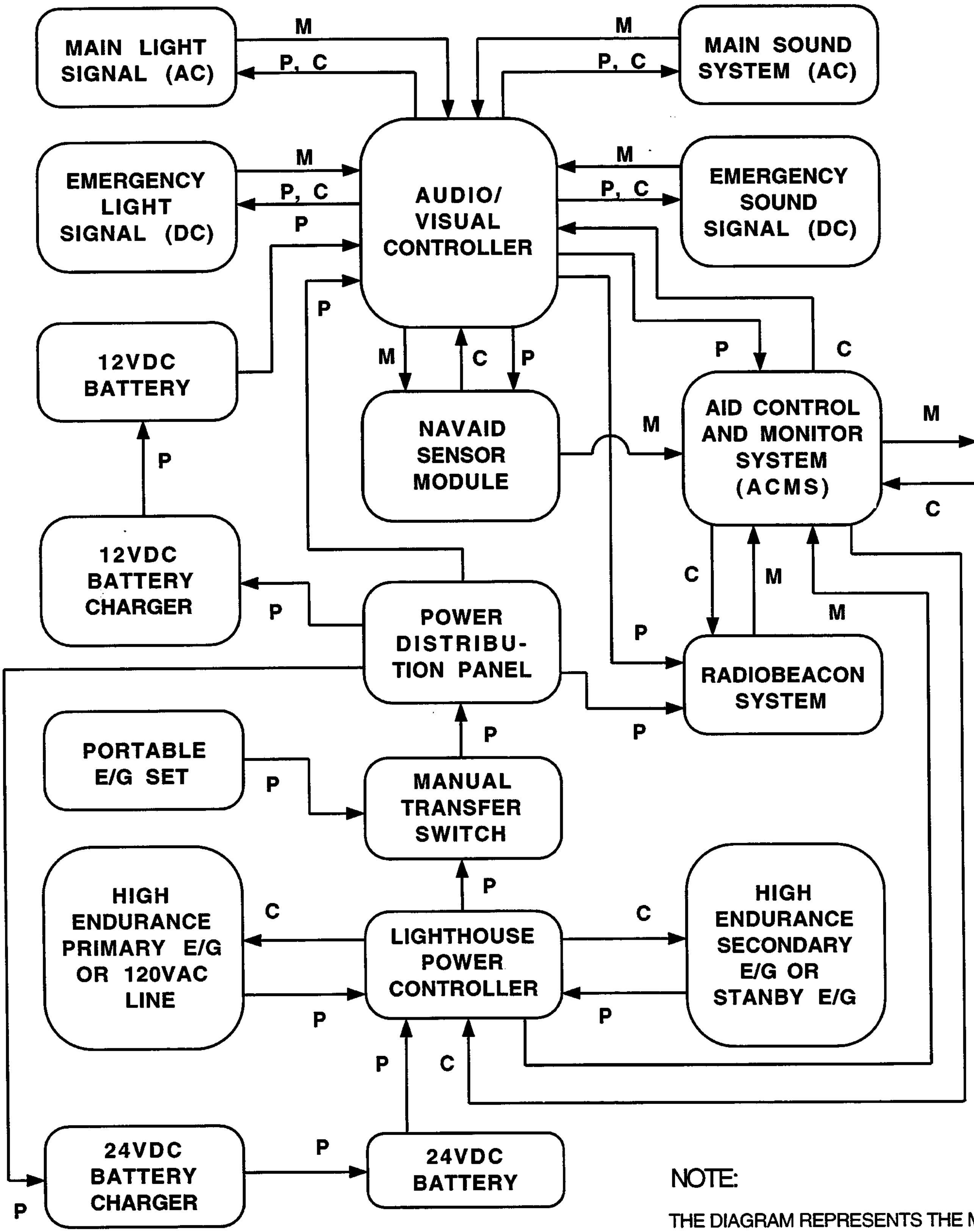


FIGURE 1-2

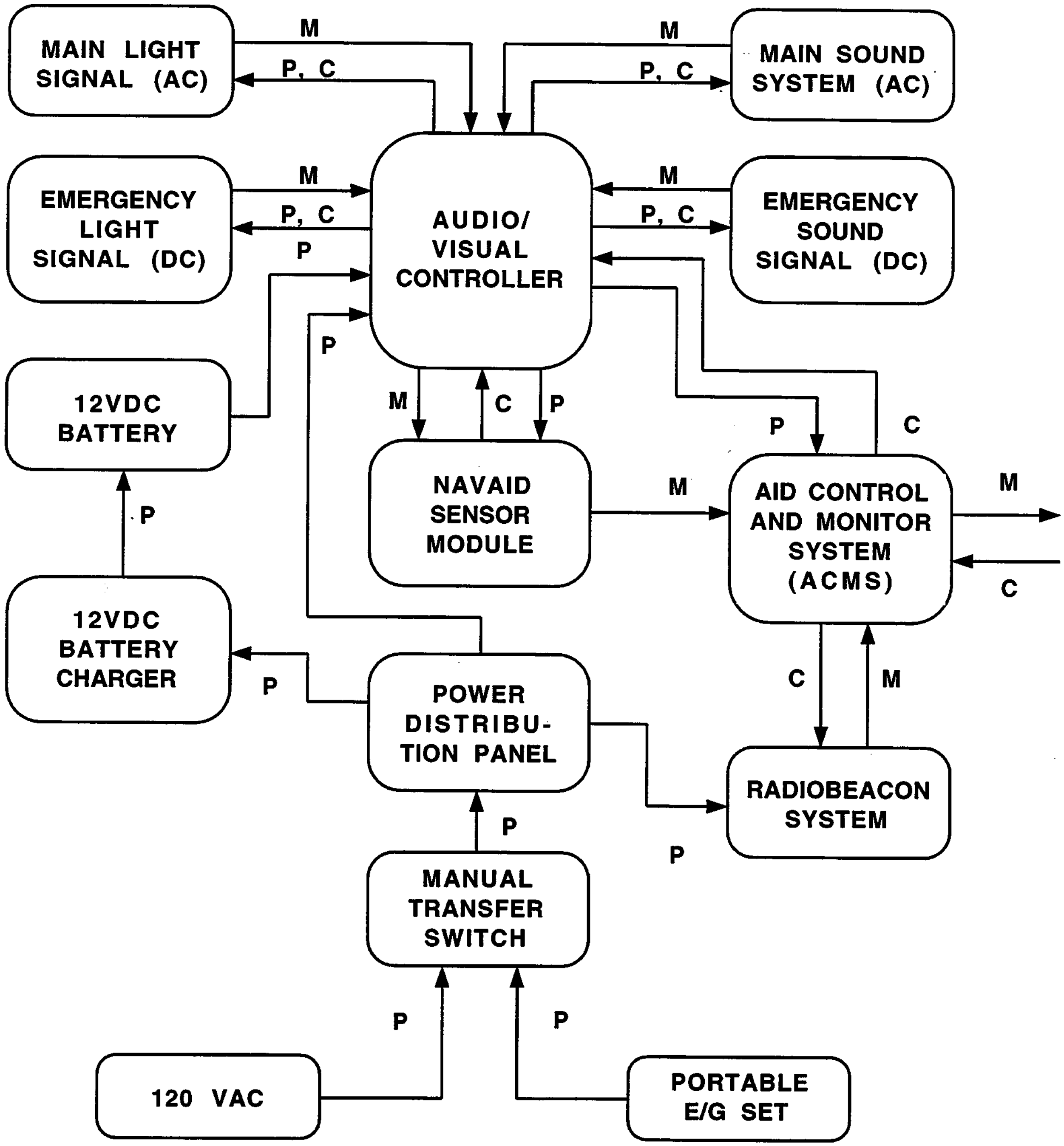
NOTE:

THE DIAGRAM REPRESENTS THE MAX ARRAY OF SIGNAL EQUIPMENT. THE ACTUAL ARRAY SHOULD BE CHOSEN TO MEET OPERATIONAL NEEDS.

CATEGORY II

FOG DETECTOR &/OR ACMS CONTROL OF SOUND SIGNAL IS OPTIONAL

SYMBOLS: M = MONITOR, P = POWER, C = CONTROL



NOTE:

THE DIAGRAM REPRESENTS THE MAX ARRAY OF SIGNAL EQUIPMENT. THE ACTUAL ARRAY SHOULD BE CHOSEN TO MEET OPERATIONAL NEEDS.

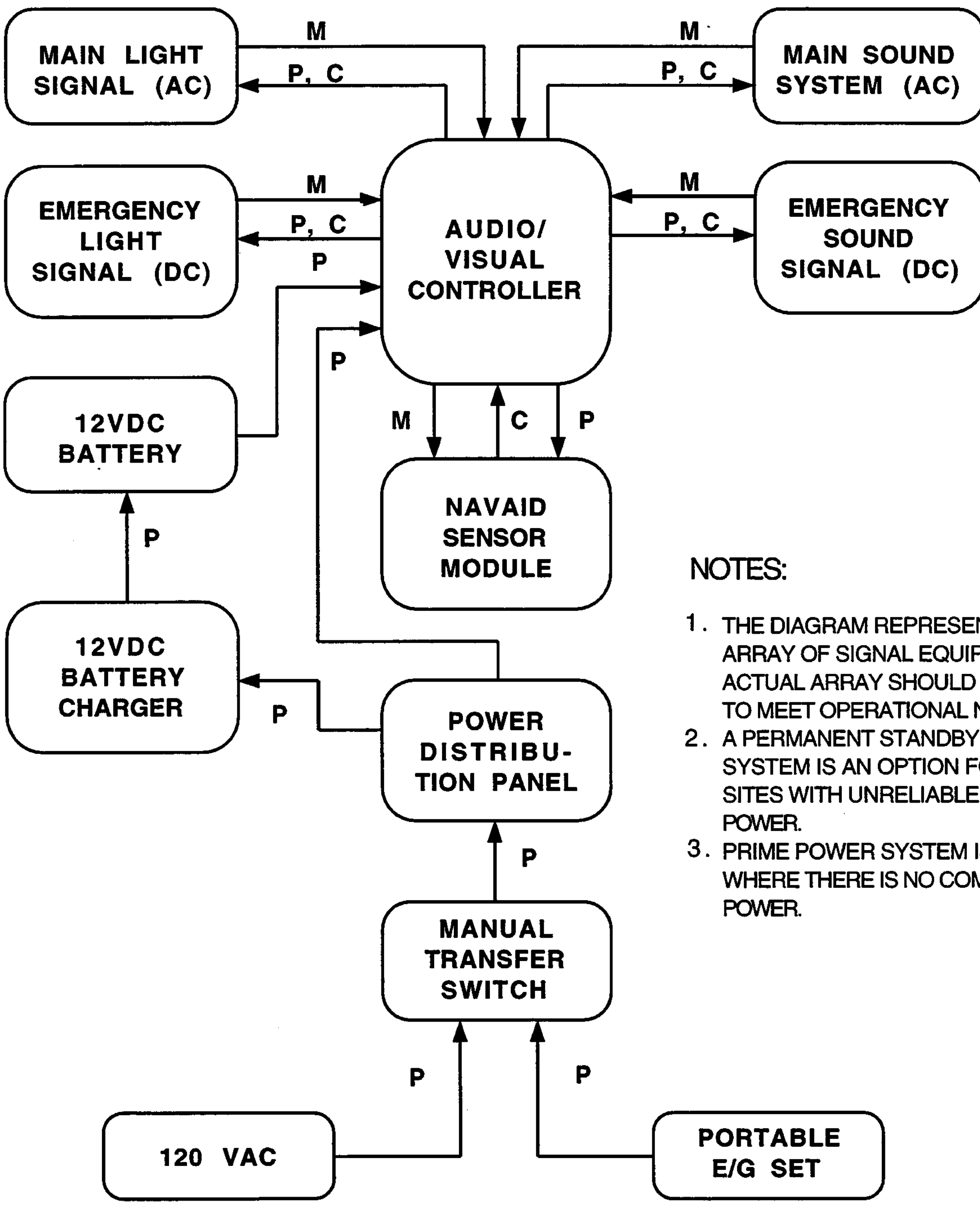
FIGURE 1-3

CATEGORY III

OPTIONS:

DAYLIGHT CONTROL OF MAIN LIGHT SIGNAL;
FOG DETECTOR CONTROL OF SOUND SIGNAL

SYMBOLS: M = MONITOR, P = POWER, C = CONTROL



NOTES:

1. THE DIAGRAM REPRESENTS THE MAX ARRAY OF SIGNAL EQUIPMENT. THE ACTUAL ARRAY SHOULD BE CHOSEN TO MEET OPERATIONAL NEEDS.
2. A PERMANENT STANDBY POWER SYSTEM IS AN OPTION FOR INDIVIDUAL SITES WITH UNRELIABLE COMMERCIAL POWER.
3. PRIME POWER SYSTEM IS AN OPTION WHERE THERE IS NO COMMERCIAL POWER.

FIGURE 1-4

CATEGORY IV

OPTIONS:

A. DAYLIGHT CONTROL OF MAIN LIGHT
B. FOG DETECTOR CONTROL OF SOUND SIGNAL

SYMBOLS: P = POWER, C = CONTROL

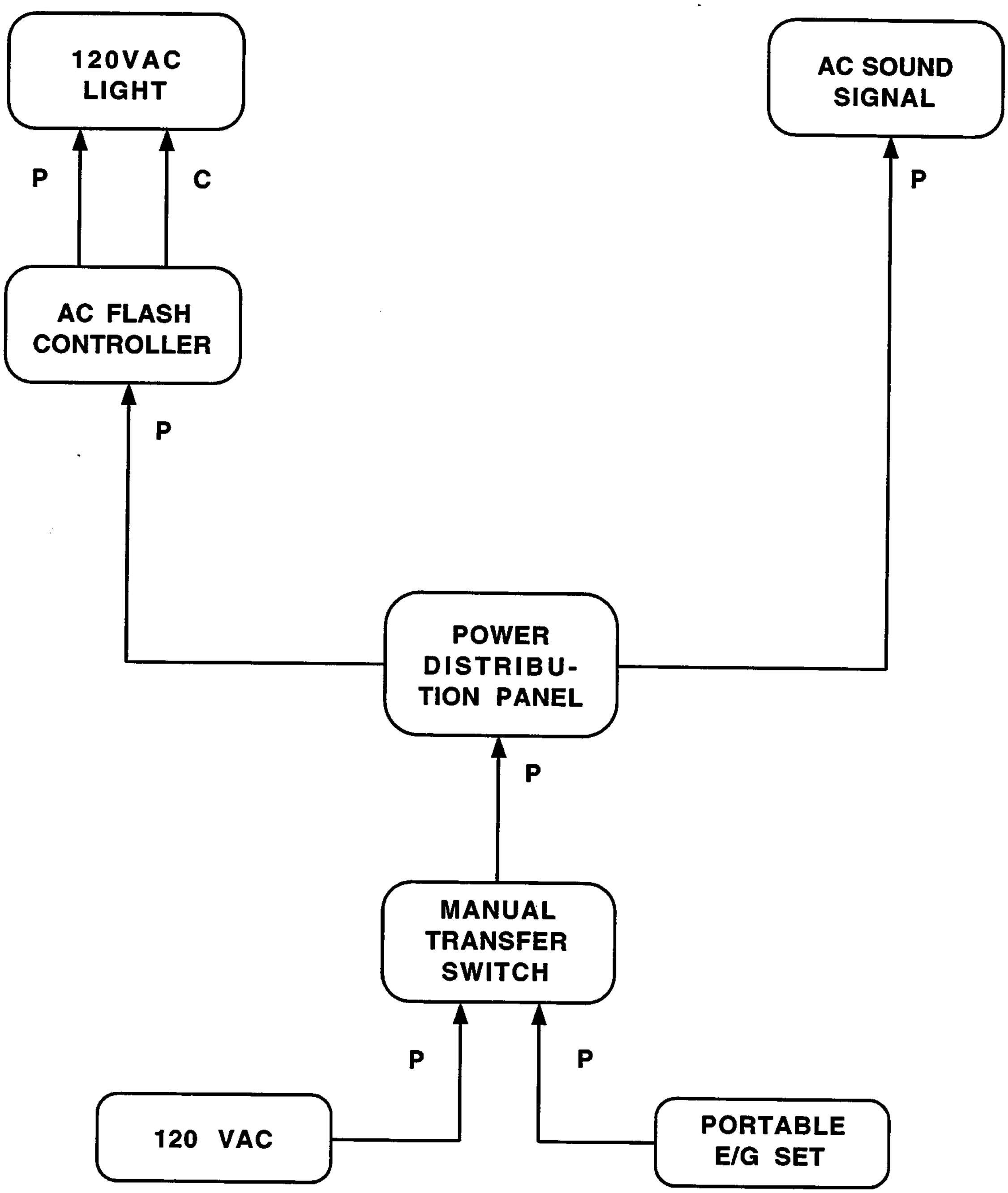
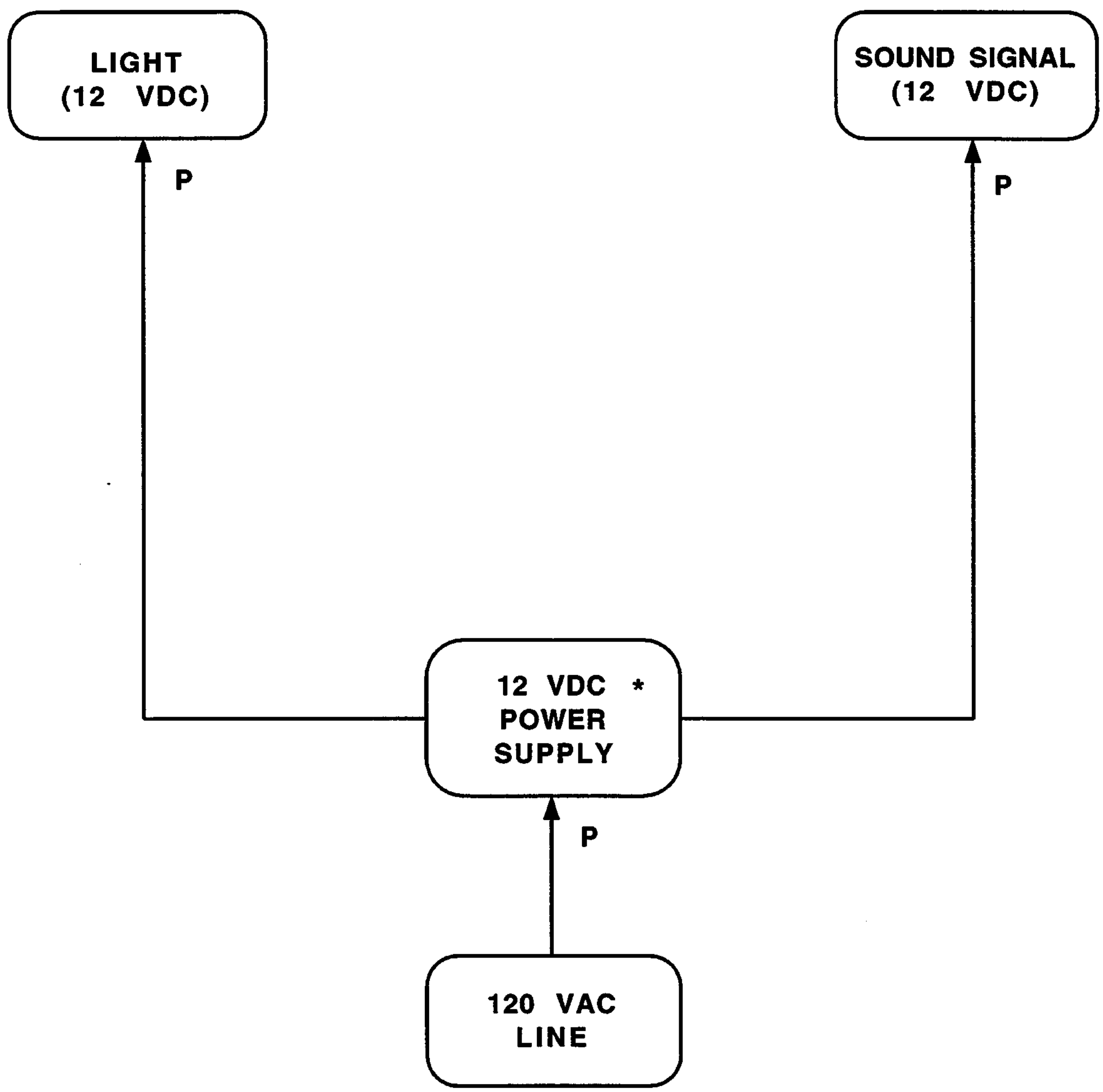


FIGURE 1-5

CATEGORY V

120VAC-RECTIFIED AND STEPPED DOWN 12VDC OR
OPTIONAL BATTERY CHARGER AND SECONDARY BATTERY

SYMBOLS: P = POWER



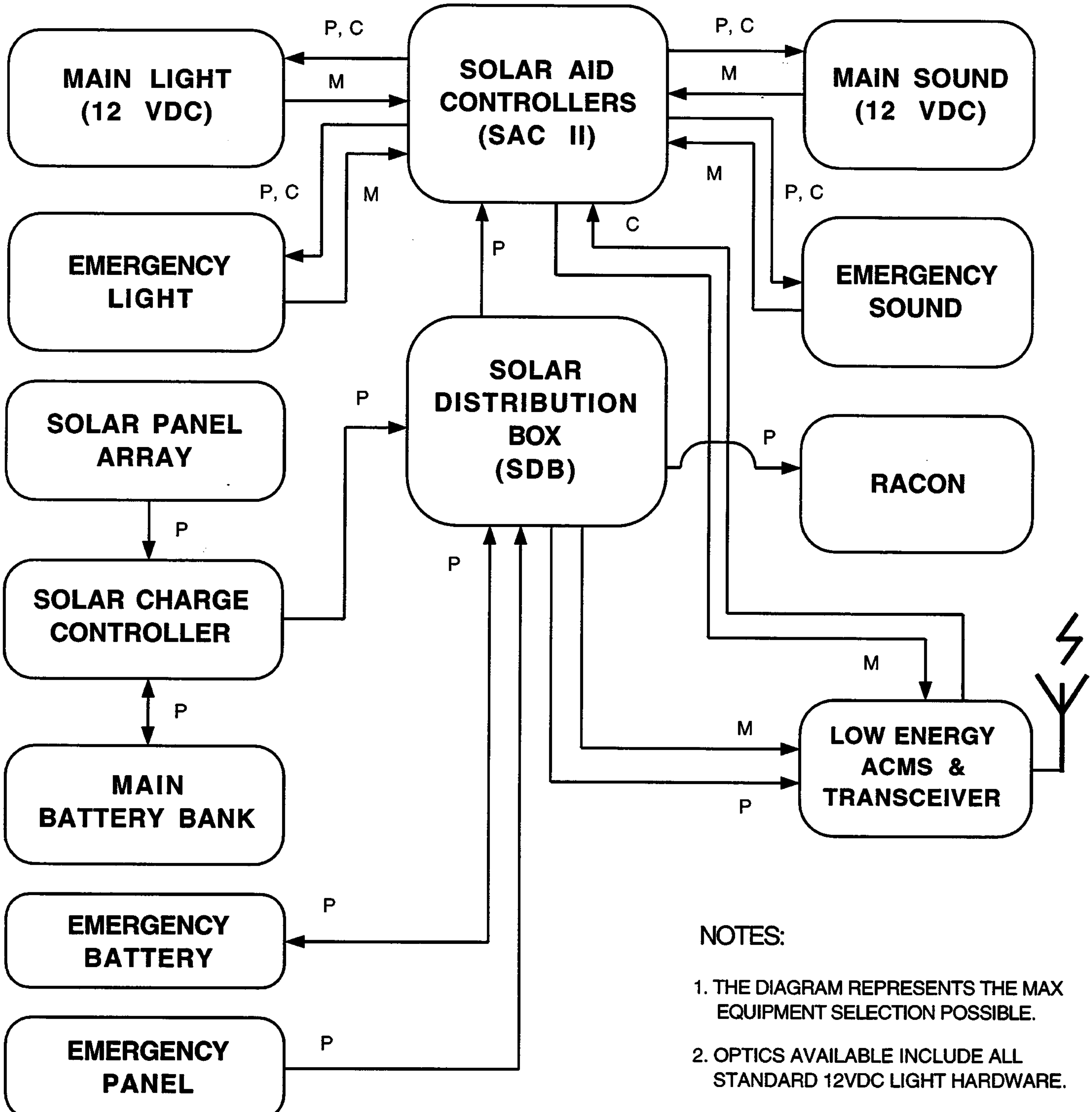
* NOTE:

OPTIONAL USE OF 12 VDC
SECONDARY BATTERY
AND CHARGER

FIGURE 1-6

SOLAR CATEGORY I

SOLAR POWERED, MONITORED AND CONTROLLED, WITH RACON, EMERGENCY SIGNALS, AND SOLAR DISTRIBUTION BOX (SDB)



NOTES:

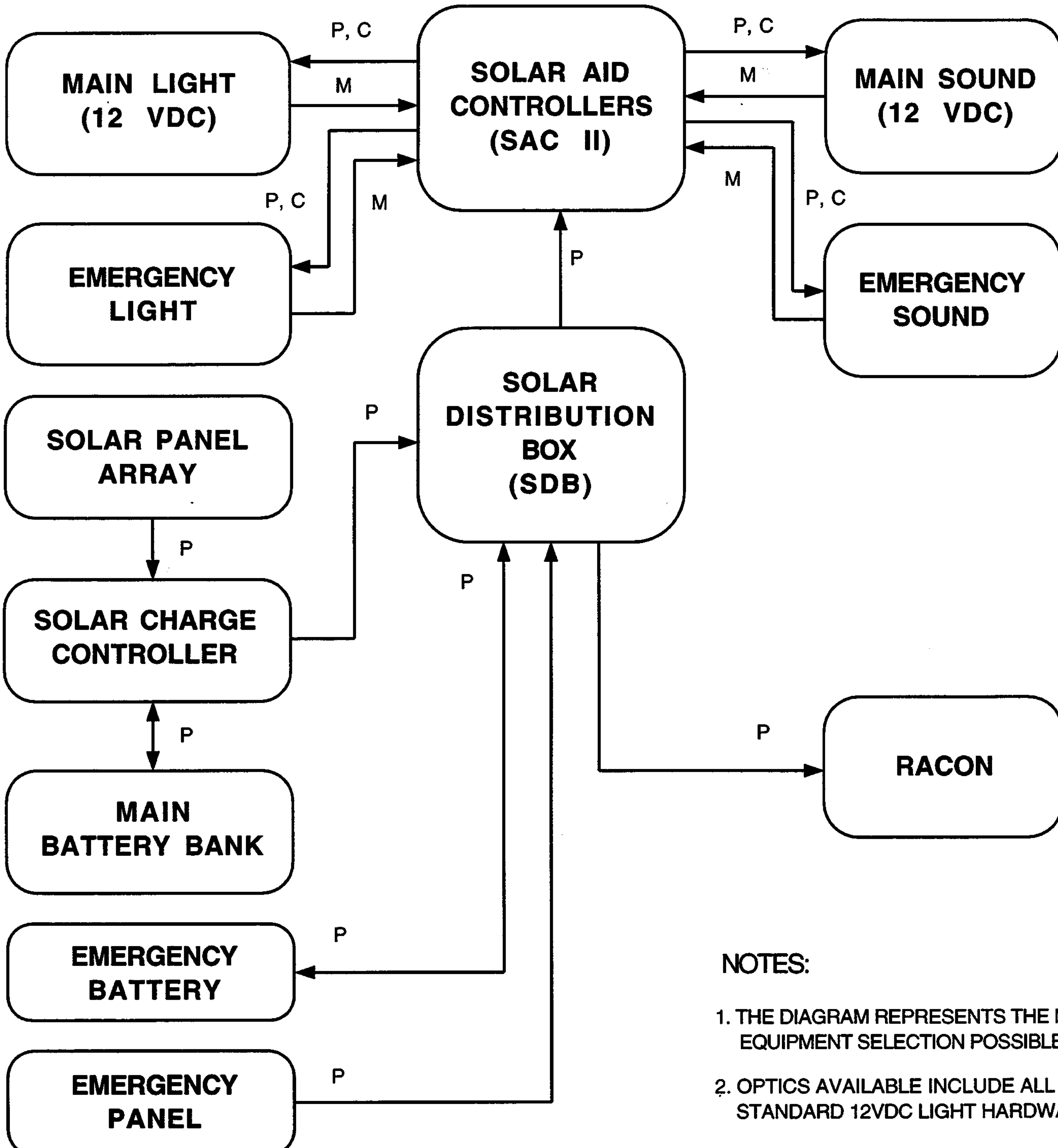
1. THE DIAGRAM REPRESENTS THE MAX EQUIPMENT SELECTION POSSIBLE.
2. OPTICS AVAILABLE INCLUDE ALL STANDARD 12VDC LIGHT HARDWARE.
3. THE SOUND SIGNAL IS THE FA-232 TYPE.

SYMBOLS: M = MONITOR
P = POWER
C = CONTROL

FIGURE 1-7

SOLAR CATEGORY II

SOLAR POWERED, WITH EMERGENCY SIGNALS, OPTIONAL
RACON, AND SOLAR DISTRIBUTION BOX (SDB)



NOTES:

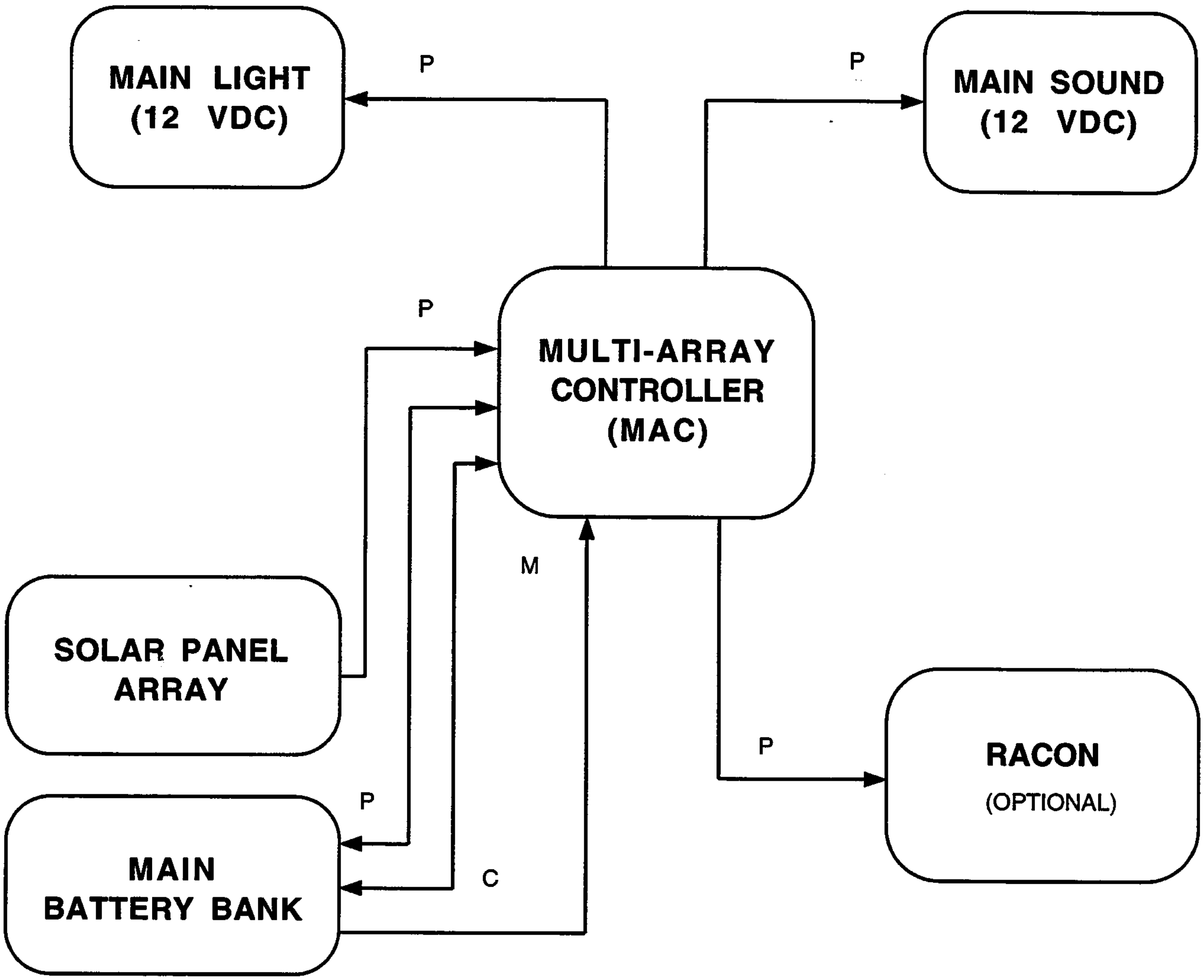
1. THE DIAGRAM REPRESENTS THE MAX EQUIPMENT SELECTION POSSIBLE.
2. OPTICS AVAILABLE INCLUDE ALL STANDARD 12VDC LIGHT HARDWARE.
3. THE SOUND SIGNAL IS THE FA-232 TYPE.

SYMBOLS: M = MONITOR
P = POWER
C = CONTROL

FIGURE 1-8

SOLAR CATEGORY III

SOLAR POWERED, WITH OPTIONAL RACON



SYMBOLS: M = MONITOR
P = POWER
C = CONTROL

NOTES:

1. THE DIAGRAM REPRESENTS THE MAX EQUIPMENT SELECTION POSSIBLE.
2. OPTICS AVAILABLE INCLUDE ALL STANDARD 12VDC LIGHT HARDWARE.
3. THE SOUND SIGNAL IS THE FA-232 TYPE.

FIGURE 1-9

RANGE CATEGORY SELECTION AID

Range Category Definitions

I: Com'l Power, RLC, Day/Night 120VAC & 12VDC Signals, Synch Day/Night Switching, Optional ACMS Monitor, Ref Dwg 130415

II: Com'l Power Night-Only Light Signals 120VAC Signals

III: Day Mark

Solar I: Solar Power, RLC, Day/Night 12VDC Signals, Synch Day/Night Switching, Optional ACMS Monitoring, Ref Dwg 140415

Solar II: Solar Power, Night-Only Light, 12VDC Signals

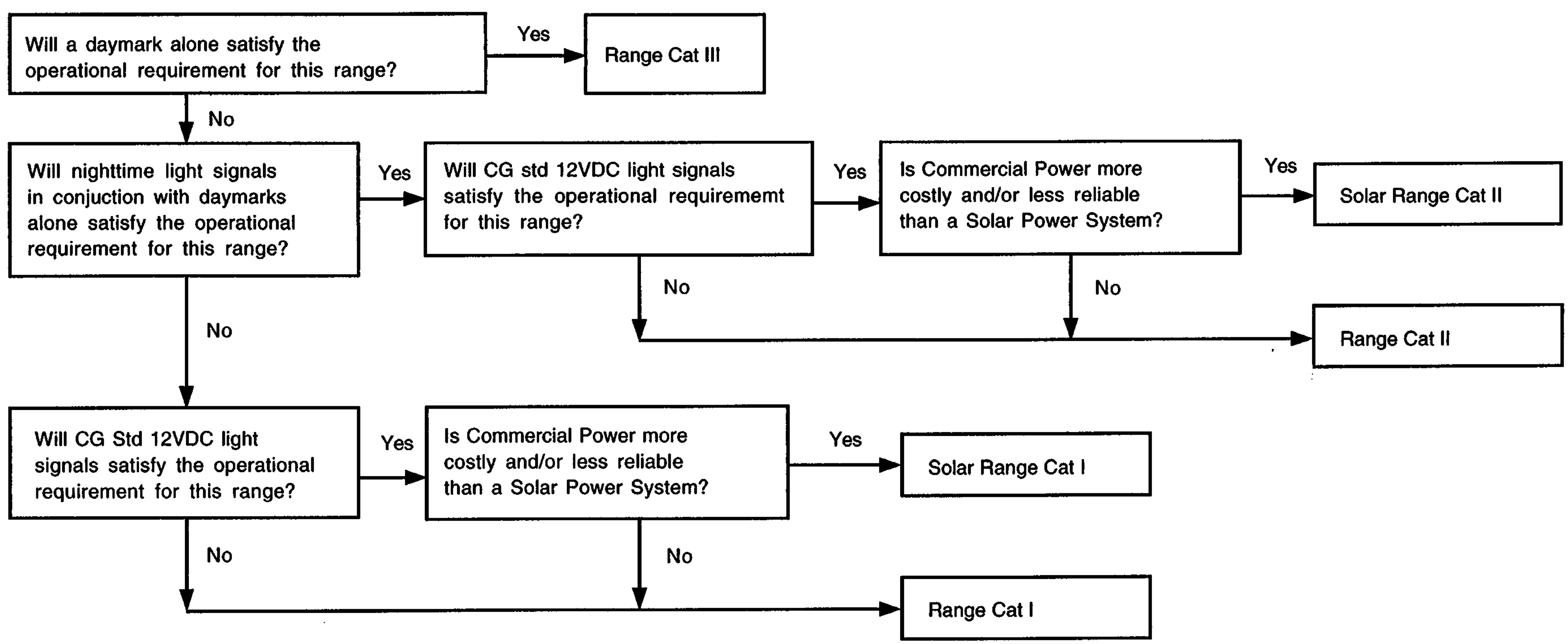
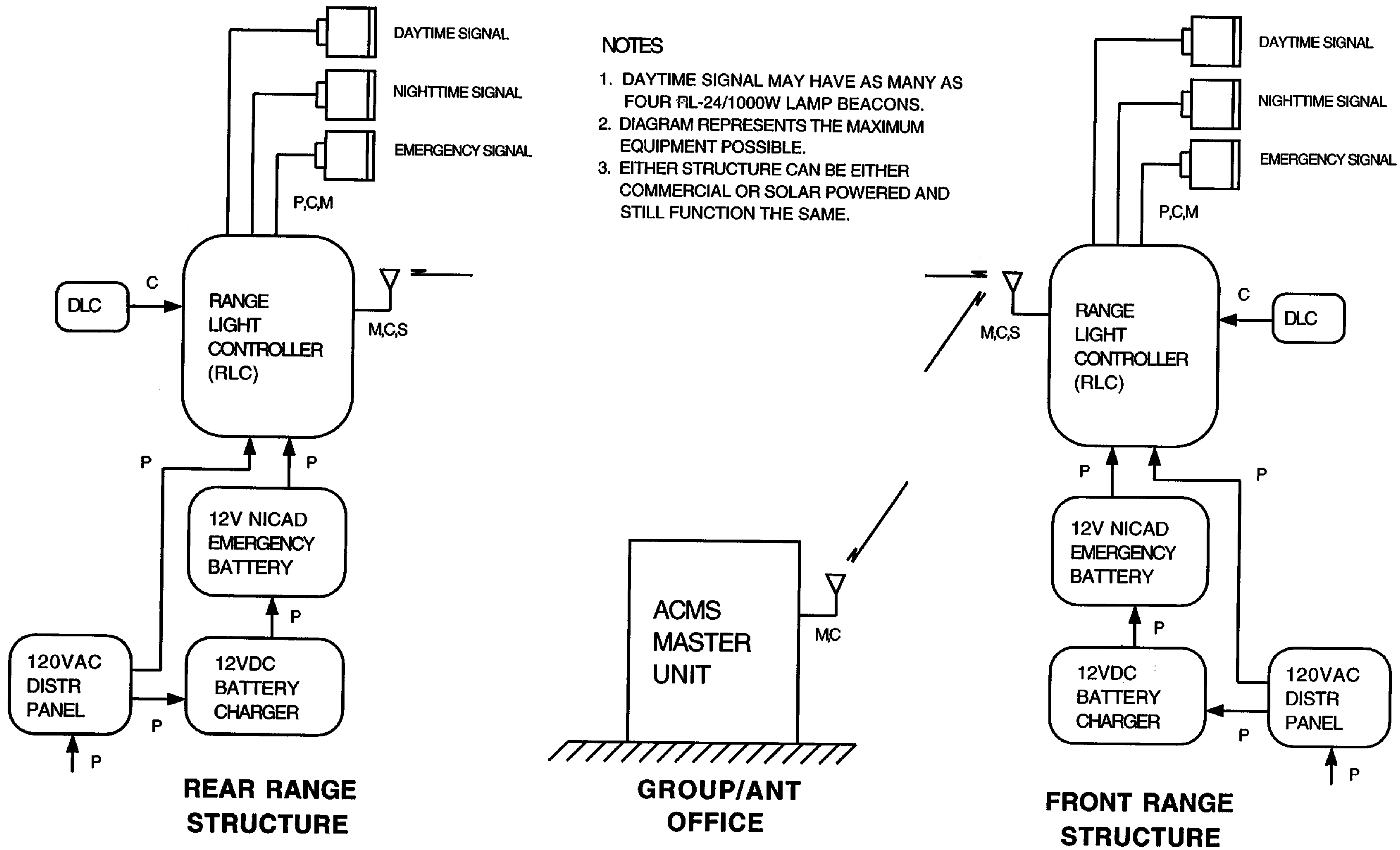


FIGURE 1-10

RANGE CATEGORY I (DAY/NIGHT)

120VAC POWERED, WITH EMERGENCY SIGNALS AND OPTIONAL ACMS MONITOR



NOTES

1. DAYTIME SIGNAL MAY HAVE AS MANY AS FOUR RL-24/1000W LAMP BEACONS.
2. DIAGRAM REPRESENTS THE MAXIMUM EQUIPMENT POSSIBLE.
3. EITHER STRUCTURE CAN BE EITHER COMMERCIAL OR SOLAR POWERED AND STILL FUNCTION THE SAME.

SYMBOLS:
M = MONITOR; P = POWER
C = CONTROL
S = SYNCHRONIZE F&R SIGNALS
DLC = DAY LIGHT CONTROLLER

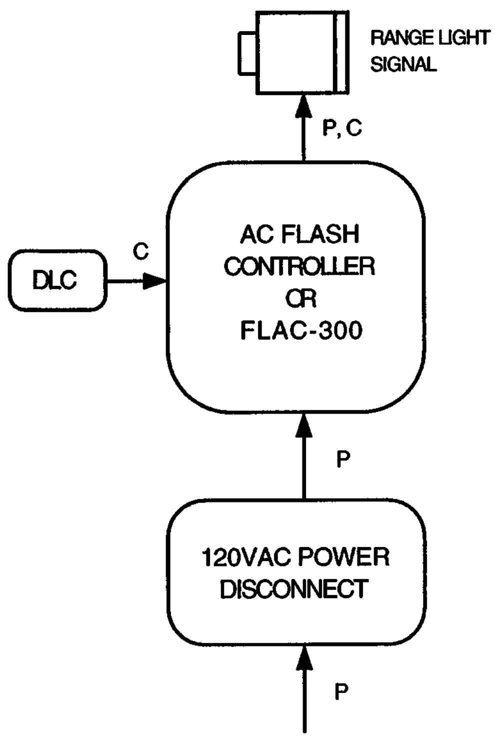
FIGURE 1-11

RANGE CATEGORY II (NIGHTTIME)

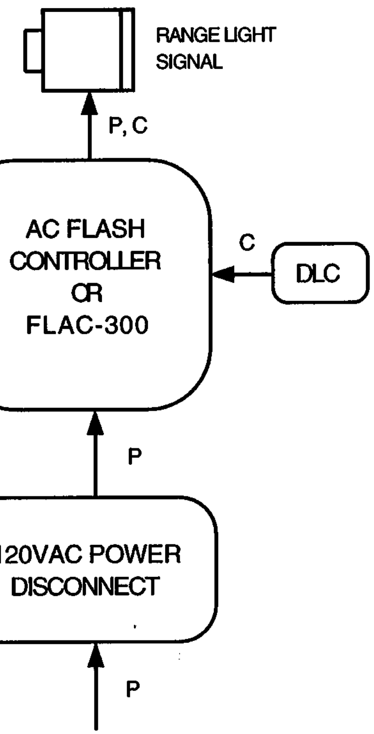
120VAC POWERED RANGE LANTERNS

NOTES

1. OPTICS AVAILABLE INCLUDE RL-14, RL-24 AND ALL 120VAC & 12VDC MARINE SIGNAL LAMPS.
2. FRONT AND REAR SIGNALS ARE INDEPENDENT OF EACH OTHER. EITHER MAY BE SOLAR OR COMMERCIAL POWERED; FUNCTION WILL REMAIN UNCHANGED.



REAR RANGE STRUCTURE



FRONT RANGE STRUCTURE

SYMBOLS: M = MONITOR
P = POWER
C = CONTROL

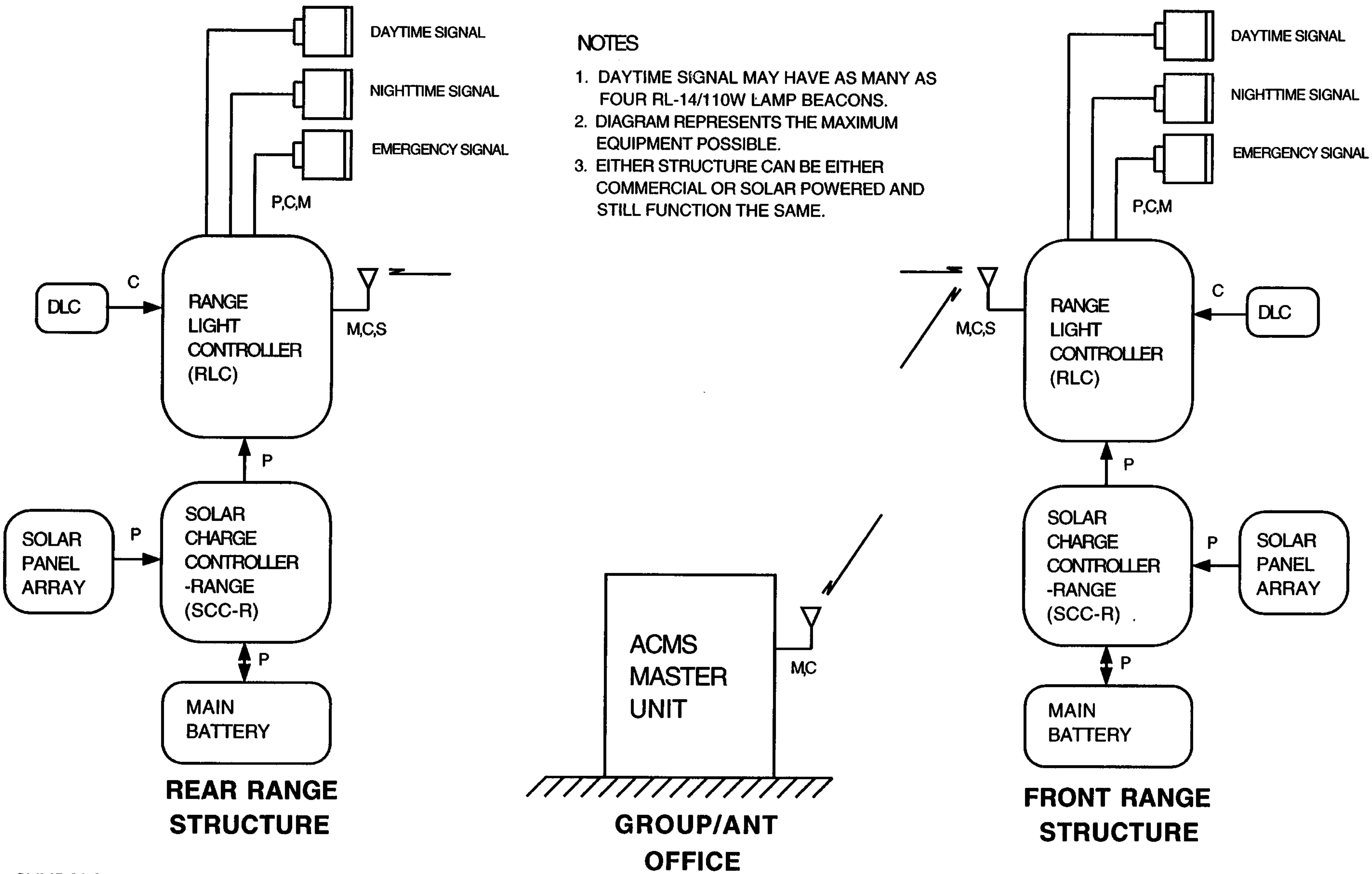
FIGURE 1-12

SOLAR RANGE CATEGORY I (DAY/NIGHT)

SOLAR POWERED, WITH EMERGENCY SIGNALS AND OPTIONAL ACMS MONITOR

NOTES

1. DAYTIME SIGNAL MAY HAVE AS MANY AS FOUR RL-14/110W LAMP BEACONS.
2. DIAGRAM REPRESENTS THE MAXIMUM EQUIPMENT POSSIBLE.
3. EITHER STRUCTURE CAN BE EITHER COMMERCIAL OR SOLAR POWERED AND STILL FUNCTION THE SAME.



SYMBOLS: M = MONITOR; P = POWER
C = CONTROL
S = SYNCHRONIZE F&R SIGNALS
DLC = DAY LIGHT CONTROLLER

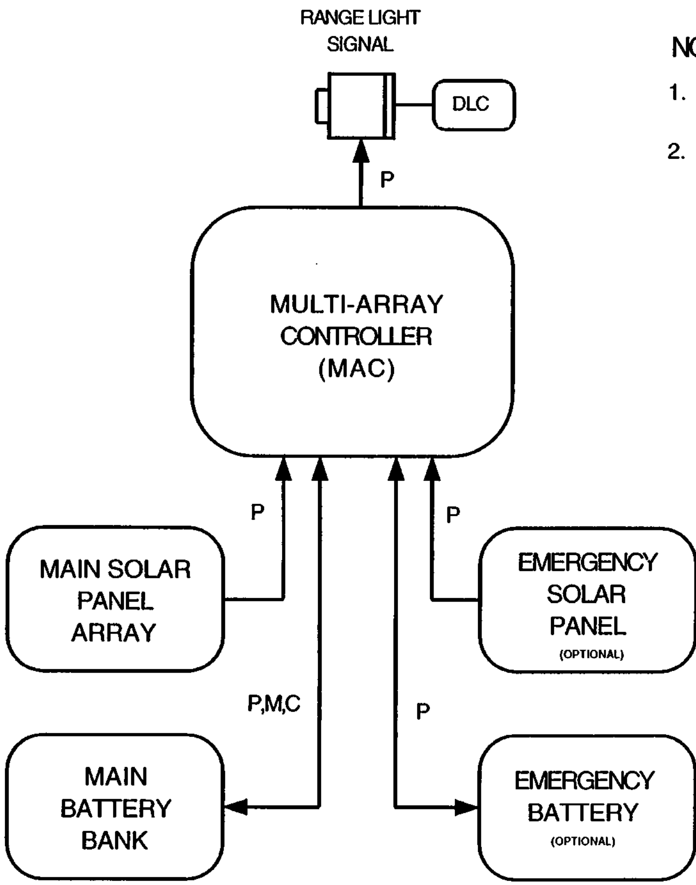
FIGURE 1-13

SOLAR RANGE CATEGORY II (NIGHTTIME)

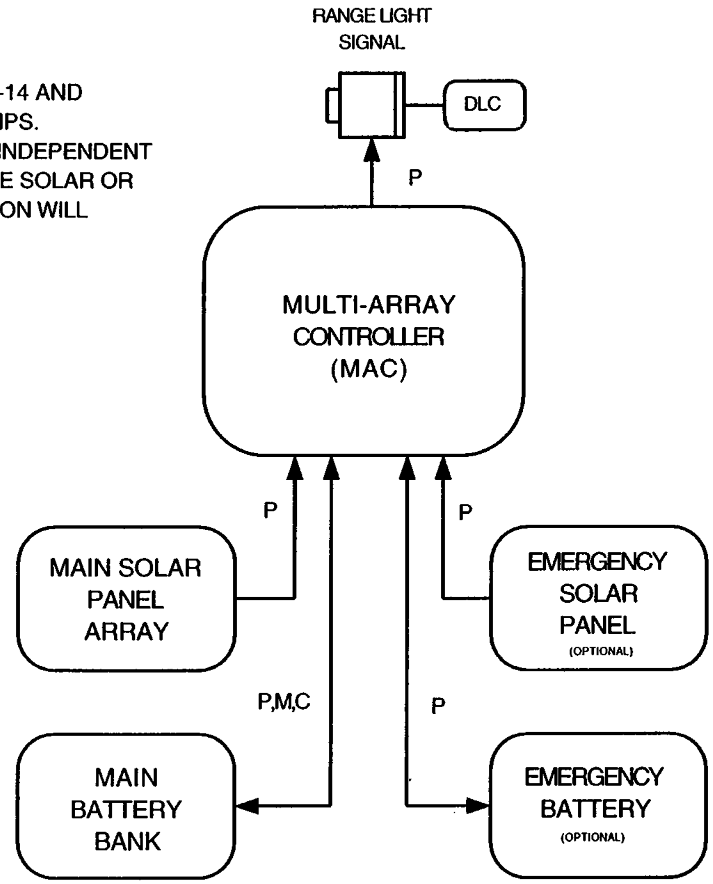
SOLAR POWERED, OPTIONAL EMERGENCY BATTERY

NOTES:

1. OPTICS AVAILABLE INCLUDE RL-14 AND ALL 12VDC MARINE SIGNAL LAMPS.
2. FRONT AND REAR SIGNALS ARE INDEPENDENT OF EACH OTHER. EITHER MAY BE SOLAR OR COMMERCIAL POWERED: FUNCTION WILL REMAIN UNCHANGED.



REAR RANGE STRUCTURE

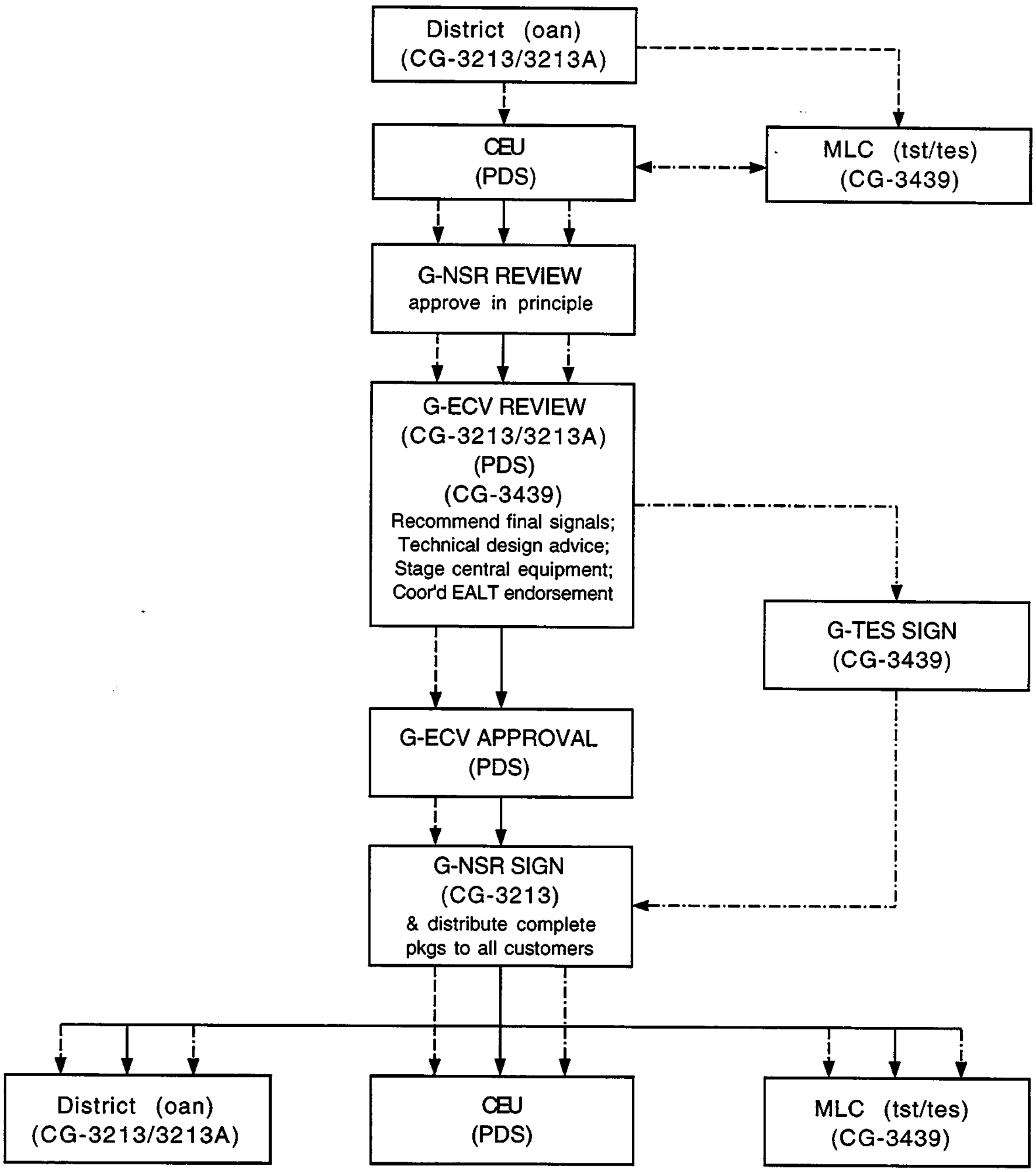


FRONT RANGE STRUCTURE

SYMBOLS: M = MONITOR; P = POWER; C = CONTROL

FIGURE 1-14

PROJECT DOCUMENTATION APPROVAL PROCESS



--------------- AIDS TO NAVIGATION OPERATION REQUEST (CG-3213/3213A)

——————— PROJECT DEVELOPMENT SUBMITTAL (PDS)

-.-.-.-.-.-.-.-. ELECTRONALT (CG-3439)

FIGURE 1-15

CHAPTER 2. LIGHT AND SOUND SIGNALS

A. General. The standard light signals and sound signals for modernizing and solarizing major aids (lighthouses and ranges) are described in this chapter. Also discussed are standard equipment to monitor and control the operation of light and sound signals and fog detectors, and the retention of certain existing signal systems. This chapter is broken down into sections on Standard 120VAC Lighthouses, Standard 12VDC Solar Lighthouses, Standard 120VAC Ranges, and Standard 12VDC Solar Ranges. Each section outlines the optics, sound signals, control and monitor equipment and ancillary equipment which may be used at a site. Power systems for these various aid types are discussed in Chapter 3. Aid monitoring systems are discussed in Chapter 4. Effective intensities for standard beacons are published in COMDTINST M16510.2, Luminous Intensities of Aids to Navigation Lights, which shall be used to select the correct beacon to meet the operational requirements of the light.

B. Standard 120VAC Lighthouses. Commandant (G-ECV) centrally procures and stocks complete single- and double-drum 24 inch, searchlight type rotating optics (DCB24 and DCB224) for use in modernization projects. A second type of 120VAC powered optic is the FA-251-AC, which has six fresnel bullseye lenses which rotate about a common focal point. The FA-251-AC may be purchased directly from the manufacturer. The DCB24/224 and FA-251-AC optics are the only 120VAC rotating optics approved for new installations. The control equipment described in this chapter will, however, work with most other existing, serviceable, AC-powered light signal optics.

All 120VAC rotating beacons procured by Commandant (G-ECV) will be furnished with the correct rotation speed, based on advance information provided by the district. Changes to rotation speed in these optics requires changing the drive motor or gearing. Speed reducers for DCB24/224 optics, as well as spare parts, are available from SUPCEN Baltimore. See COMDTINST M16500.3, Aids to Navigation Manual-Technical, for parts and stock numbers.

1. Standard 120VAC Rotating Beacons.

a. 24 Inch Rotating Beacons. The DCB24 and DCB224 optics use 24 inch parabolic mirrors to generate collimated pencil beams, which are swept across the horizon as the beacon rotates. They are equipped with horizontal-swing, two-place lampchangers that accept 1000 watt, mogul-bipost lamps. These beacons can be equipped with filters of any approved signal color and in any combination of colors. The two drums of the DCB224 can be set to any angle to provide either simple or group flashing (2) characteristics.

b. FA-251-AC. The FA-251-AC has six 95mm focal length bulls-eye lens panels, which rotate about a common focal point. Lenses may be of any approved signal color. Blanking panels are available to produce group flashing characteristics. The standard lamp used with the FA-251-AC is a DC-bayonet mount, 150 watt tungsten-halogen lamp.

2. Other Rotating Beacons. Other optics currently in use, including older single- and double-drum 24 inch optics, the 36 inch diameter refracting lens beacons (DCB36/236), and various rotating classical fresnel lenses, may be retained if a reliable spare parts source is available to facilitate timely repairs.

a. Rotating Classical Lenses. Classical lenses are of special historical interest. Classical lenses rotating on mercury floats should be modified, if possible, or replaced because of the special maintenance and safety requirements of this system. Classical lenses using other rotating systems, which remain serviceable, should be retained. Any modification or replacement of a classical lens must be coordinated with the appropriate historic preservation interests.

b. Rotation Detectors. The DCB24/224 and FA-251-AC rotating beacons are delivered with rotation detectors installed. Existing beacons must be retrofitted to provide a form A contact closure with a duration of at least one millisecond but not more than 20 percent of the period of rotation. This contact closure is used by monitor equipment, described later in this chapter.

3. Non-rotating Optics. The primary omnidirectional lanterns for new installations are the 250mm and 300mm marine signal lanterns, which are commercially available. These lanterns are based on a molded acrylic fresnel lens. Selection of a lantern for installation must include an evaluation of power dissipation. The unvented version of the 250mm can only dissipate 75 watts, while a vented version can dissipate up to 200 watts. The 300mm can dissipate 250 watts. For AC-applications, only the 250W lamp should be used in these lanterns. Non-rotating classical lenses should be retained if serviceable. Modification or replacement of a classical lens must be coordinated with the appropriate historic preservation interests.

4. 12VDC Optics. At times, use of a 12VDC optic may be desired at a site where reliable 120VAC power is available. This may be due to the limited size of the lantern house on the structure, or for uniformity of

systems within a district. Guidance on integration of 12VDC optics, such as the VRB-25 or the 300mm lantern outfitted with 12 volt lamps, at a 120VAC-powered aid may be obtained from Commandant (G-ECV).

5. Lampchangers. Commandant (G-ECV) centrally procures and stocks the horizontal-swing, two-place lampchangers (CG-2P) for the 1000 watt, mogul-bipost lamps. The CG-2P lampchangers are the same units which are provided with the DCB24/224 optics. A four-place lampchanger (CG-4P) for the 150 watt and 250 watt DC-bayonet mount lamps is commercially available. The CG-4P is used in the FA-251-AC, as well as in many acrylic and glass omnidirectional lenses and range lanterns. Obsolete lampchangers should be replaced with the CG-2P or CG-4P, as appropriate, whenever possible.

6. Emergency Lights. When required, emergency lights shall normally be provided by standard 12VDC omnidirectional lanterns, equipped with CG-181 flashers and CG-6P lampchangers, and lamped with standard 12VDC marine signal lamps. The emergency light should have the same characteristic as the main light. Nonstandard CG-181 flashers may be special ordered from manufacturers listed on the CG-181 Qualified Products List (QPL), maintained by Commandant (G-ECV). If there is an operational requirement for greater range than can be provided by a 12VDC omnidirectional lantern, or a requirement for an alternating characteristic, the standard 12VDC rotating beacon may be used for the emergency light. Section C discusses the 12VDC optics, lampchanger and flasher in more detail.

7. Sound Signals. Standard sound signals are the 120VAC, 300Hz, CG-1000 power supply with ELG-300/02 directional emitter, and the 12VDC, 390Hz, omnidirectional, twin-emitter FA-232/02. The 500Hz ELG-500/02 and ELG-500/04 directional emitters may be used with the CG-1000 power supply, but are reserved for situations when use of the standard sound signals could be confusing to the mariner due to the proximity of other sound signals. The use of twin CG-1000 power supplies with an ELG-300/04 emitter is discouraged, as there is no longer a general requirement for sound signals with a range greater than two nautical miles.

   a. CG-1000 System. The CG-1000 with an ELG-300/02 emitter generates a Sound Pressure Level (SPL) of 133-143 dBC, depending on the output setting of the horn level control; corresponding to a usual audible range of two to three nautical miles. Commandant (G-TES) centrally stocks spare parts for this system to maintain existing 120VAC sound signals. New systems are available through Commandant (G-ECV).

b. FA-232/02. The FA-232/02 generates an SPL of 128.7 dBC, which corresponds to a usual audible range of one nautical mile. The horn may be plugged to convert it to a directional emitter. COMDTINST M16500.3 provides information on this procedure. Commandant (G-TES) periodically buys FA-232/02 sound signals and spare parts to meet ongoing and new requirements. A four emitter version of this sound signal, the FA-232/04, is available for aids which have an operational requirement for a two nautical mile sound signal. The FA-232/04 is available for purchase direct from the manufacturer.

8. Emergency Sound Signals. The standard emergency sound signal is the 12VDC, 390Hz, omnidirectional FA-232, with an SPL of 122.7 dBC (usual audible range of 0.5 nautical mile). Like the FA-232/02, this horn may be converted to a directional emitter by plugging a section of the horn. When operationally required, the FA-232/02 may be used as an emergency sound signal.

9. 120VAC Light Control Systems. The equipment discussed here is for control of the light signal itself, and is not part of the Aid Control and Monitor System (ACMS). It does, however, provide the inputs to the ACMS for remote monitoring of the signal status.

a. Audio-Visual Controller (AVC). The Audio Visual Controller (AVC), GCF-RWL-2098, is used to control both rotating and flashed 120VAC lights where an emergency light is needed or where light status must be remotely monitored. This includes all Category I, II and III Lighthouses. All light signal electrical connections are made to the AVC. The AVC contains a lamp current detector and applies the output of this detector (plus the output of a rotation detector on rotating optics) to the Navaid Sensor Module, which checks for the correct period. Upon detection of a failure, the Navaid Sensor Module returns a control signal to the AVC, which secures the main light and energizes the emergency light. The AVC includes circuitry for lampchanger position monitoring as well. Lampchanger status connections are explained in the AVC manual and on the standard installation and troubleshooting drawings listed in Chapter 7.

b. Equipment Interconnections. The wiring diagram for an AVC, a Navaid Sensor Module, a DCB24 rotating beacon and an emergency light is depicted in Figure 2-1. Many system functions and components, such as reset timers, power on delay timers, and circuit breakers, have been omitted to simplify explanation. Detailed interconnection and trouble-shooting drawings are included in the list of standard drawings in Chapter 7. Detailed circuit and logic explanations are included in the AVC and Navaid Sensor Module manuals.

(1) Referring to Figure 2-1, 120VAC from the AVC is connected directly to the rotation motor on the DCB24/224. Main light power is routed through a control relay to a solid state switch and from there through a current detector to the beacon lamp(s). The detector is preset at the factory, but may be adjusted to meet other required levels (ie: two lamps in a DCB224).

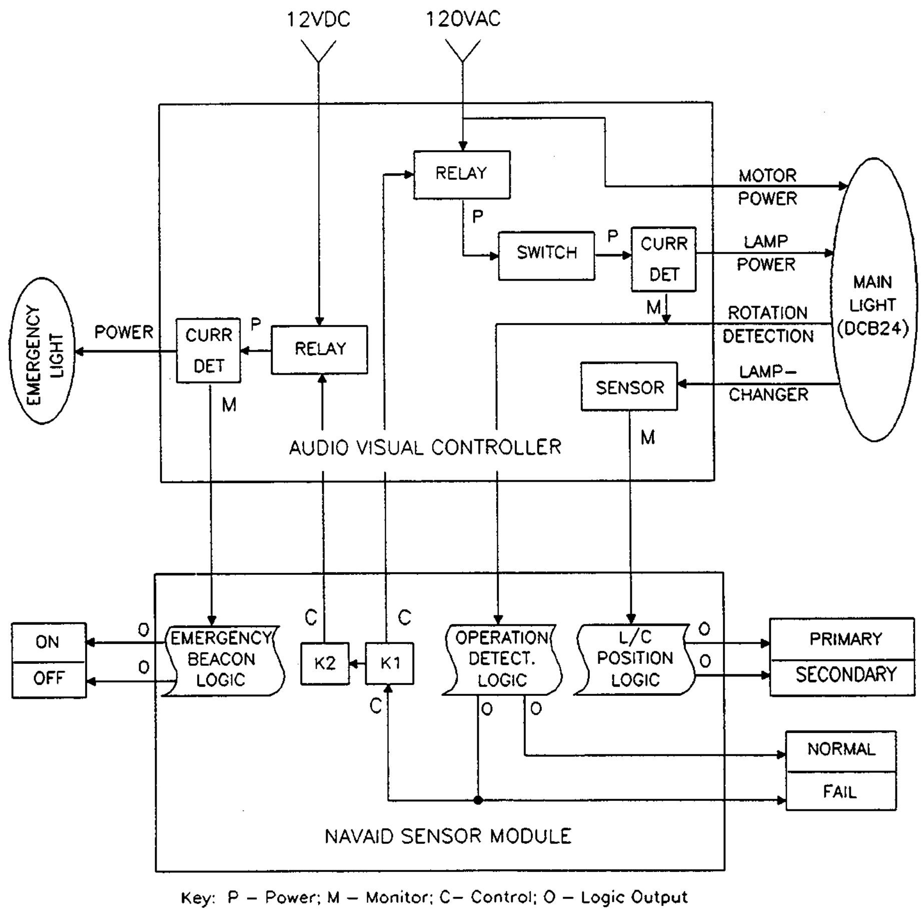


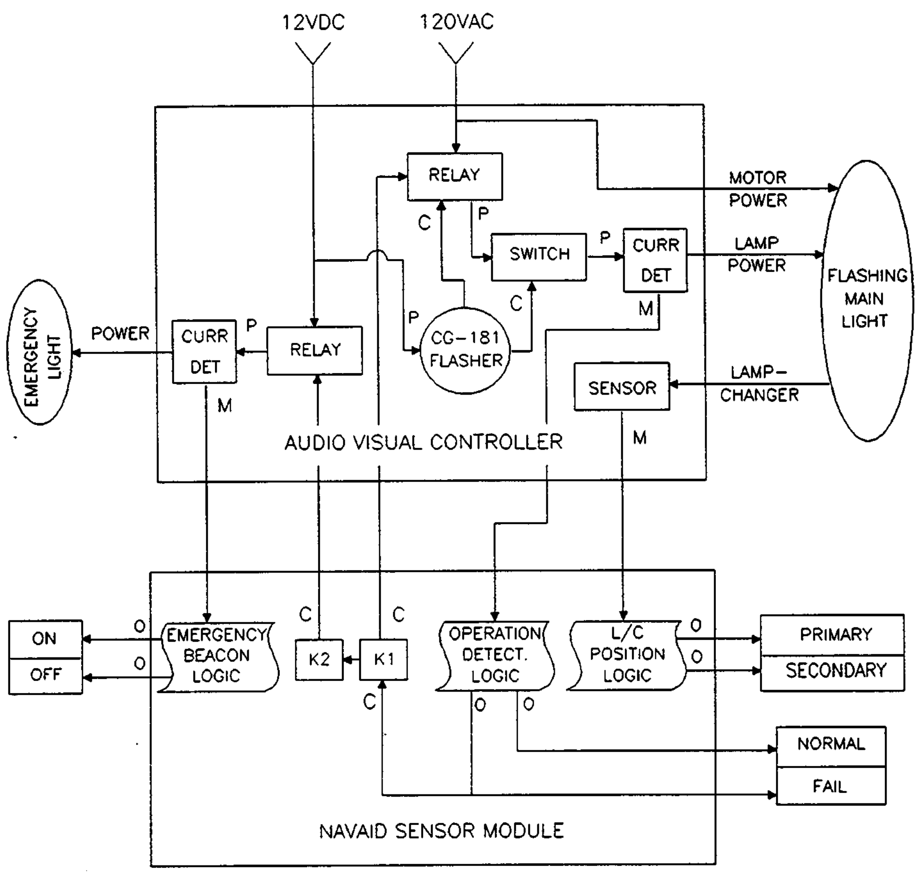
Figure 2-1
Interconnection Diagram for Light Signal and Control Equipment
Category I, II, or III Light
(Rotating Main Light)

Output of the current detector is combined with rotation detector output from the beacon and routed to logic on the Navaid Sensor Module. The ***operation detection logic*** checks that current is flowing to the lamp and that the optic is rotating at the correct speed (see caution note on Navaid Sensor Module timing at the end of this section). The two outputs of this logic are main light **FAIL** or **NORMAL**. A **FAIL** output is applied to relay K1, on the Navaid Sensor Module, as well as to the Navaid Sensor Module status output display. The K1 contacts control operation of the power control relay in the AVC, and secure power to the lamp in the event of a rotation failure.

(2) A **FAIL** indication by the operation detection logic is also applied to relay K2 on the Navaid Sensor Module. The K2 contacts control the 12VDC power relay for the emergency light. When closed, this relay connects 12VDC power to the emergency light through a current detector. The current detector closes a contact each time the light flashes and draws current. The contact is connected to logic on the Navaid Sensor Module, which determines whether these closures are occurring at the correct period. (See caution note concerning Navaid Sensor Module timing at the end of this section.) If the logic determines that the period is correct, an emergency light **ON** output results. If the logic detects improper timing, an **OFF** output results. The emergency light will not be turned off by the Navaid Sensor Module or the AVC, even when improper operation is detected. An **OFF** indication will also result if the emergency light is turned off by a daylight control.

(3) Lampchanger position information is routed from the beacon through the AVC to logic in the Navaid Sensor Module, which has outputs of main light **PRIMARY** or **SECONDARY**. On a DCB224 installation, a **SECONDARY** output will occur if either lamp-changer is in the second position. Output of the operation detection logic is also applied to the lampchanger logic to inhibit Navaid Sensor Module lampchanger status outputs if the optic has failed.

(4) Figure 2-2 depicts operation of the AVC and Navaid Sensor Module with a flashed main light and an emergency light. Monitoring of main light operation and lampchanger status is identical, except that pulsed current through the current detector is used to determine main light period instead of rotation detector output. The main light is flashed by a solid state power switch controlled by the CG-181 flasher.



Key: P – Power; M – Monitor; C – Control; O – Logic Output

Figure 2-2
Interconnection Diagram for Light Signal and Control Equipment
Category I, II, or III Light
(Flashed Omnidirectional Main Light)

c. <u>AC Flash Controller</u>. The AC Flash Controller, GCF-RWL-2106, has been designed to flash AC lamps of up to 2000 watts where no emergency light is required and the light is not monitored. Characteristic timing is provided by a CG-181 flasher. A functional diagram of this unit is shown in Figure 2-3. The AC Flash Controller is installed in a watertight enclosure, with a receptacle for a Type L daylight control. The AC Flash Controller is furnished without the CG-181 flasher or daylight control. The AC Flash Controller is also used to control rotating 120VAC lights where there is a sound signal, but no emergency light, no requirement to monitor, and where a daylight control is used. Both of the systems described above fall under Category IV Lighthouses. (Note: The FA-251-AC has a daylight control built in, which eliminates the need for an AC Flash Controller for this beacon at a Category IV Lighthouse.)

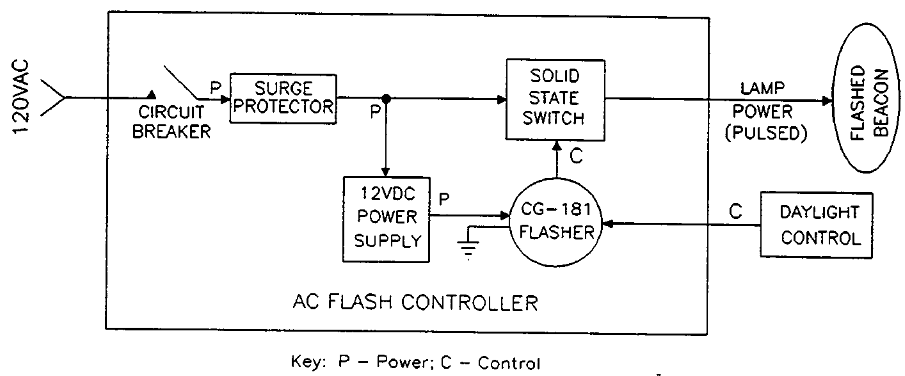


Figure 2-3
Interconnection Diagram for Light Signal and Control Equipment
Category IV Light
(Flashed Omnidirectional Light)

d. <u>FLAC-300 Flasher</u>. The FLAC-300 Flasher is used to control flashed 120VAC signals, with lamps of up to 250 watts, at aids where there is no emergency light and the aid is not monitored. For the 250mm and 300mm lanterns, the FLAC-300 is installed on the lampchanger-flasher bracket below the CG-4P. A Type L daylight control can be connected to the FLAC-300.

e. Daylight Control. For Category I, II and III Lighthouses, the main light shall remain in operation at all times, based on the following reasoning:

(1) increased reliability due to simplified control and monitor sensing; and

(2) increased service to the mariner in periods of rain and other sight visibility reductions which might not have otherwise activated the light.

On monitored aids, emergency lights shall not be daylight controlled. The reason for this is that the monitor equipment is secured after the first 30 minutes of a continual power failure. It would, therefore, not be possible to definitely ascertain the status of the emergency light if there were a daytime power failure and the emergency light was daylight controlled. Emergency lights on unmonitored aids may be daylight controlled.

f. Uncontrolled. A 120VAC rotating or omnidirectional beacon with a fixed characteristic may also be operated without control, if there are no emergency signals present, the aid is not remotely monitored, and daylight control is not required.

10. Sound Signal Control Systems. CG-1000 and FA-232 sound signals have integrated timing circuits, and can be connected directly to power without auxiliary control equipment. However, if the sound signal must be remotely monitored or is backed up by an emergency sound signal, an AVC and Navaid Sensor Module are required. The AVC controlling the main and emergency light is also used for sound signal control, as it contains both light and sound signal circuitry. An identical, but separate, Navaid Sensor Module is required.

a. Primary Sound Signal. Operation of a CG-1000 sound signal system, with an emergency sound signal, AVC, Navaid Sensor Module, and fog detector (discussed later in this chapter) is diagramed in Figure 2-4. Several auxiliary functions and controls have been omitted for clarity. Detailed interconnection and troubleshooting drawings for this and similar systems are listed in Chapter 7. The 120VAC power for the sound signal comes from the AVC. A power supply output current sampling network, set for the desired output level, is preinstalled in the CG-1000 and the output is applied to a ***timing logic*** circuit on the sensor module. If the sound signal has the correct output at the correct period, a sound signal **ON** output results. The output of the timing logic is also applied to ***system status logic***. The output of the system status logic is:

(1) **NORMAL**--the power supply is supplying correct output when the sound signal is commanded "on" by the fog detector or the power supply is turned off when commanded "off" by the fog detector; and

(2) **FAIL**--the sound signal is commanded "on" by the fog detector but is not supplying the correct output.

Output of the sound signal timing logic circuit is also applied to relay K1 on the Navaid Sensor Module. The contacts of K1 are connected to the coding controls in the sound signal power supply. If the timing logic circuit detects improper operation, the relay contacts open; securing coding and, hence, output of the connected power supply. The K1 contacts are also opened when the fog detector provides a **COMMAND OFF** signal.

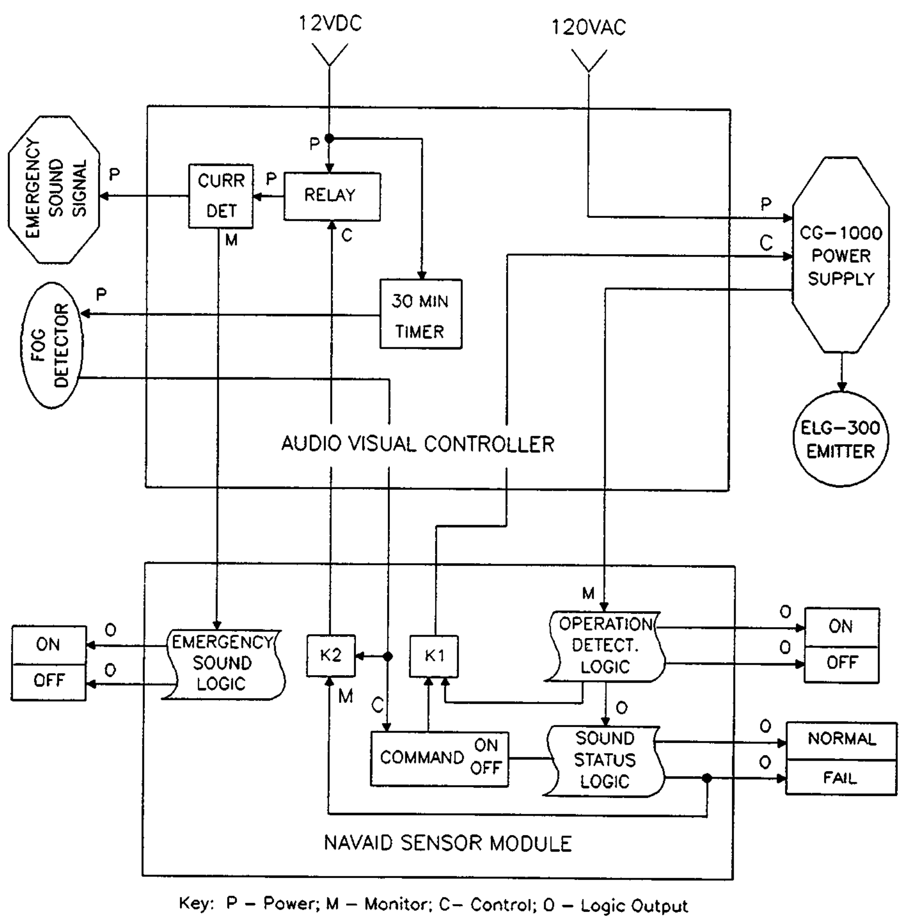


Figure 2-4
Interconnection Diagram for Sound Signal and Control Equipment
Category I, II, or III Light
(120VAC Primary Sound Signal)

b. Emergency Sound Signal. The emergency sound signal is connected to 12VDC in the AVC through a current detector and control relay. The control relay is initiated by relay K2 on the Navaid Sensor Module, which is closed when a **FAIL** signal is sent from the system status logic. Output of the emergency sound signal current detector is applied to timing logic on the sensor module. If the period of the emergency sound signal is correct, an **EMERGENCY SOUND ON** output will be present. If the emergency sound signal is turned off, or is operating with an incorrect period, an **EMERGENCY SOUND OFF** output will be present. The emergency sound signal will continue to operate even if an incorrect period is detected. To conserve battery power during an AC power failure, the fog detector is secured after 30 minutes operation by a timer in the AVC. The emergency sound signal operates on a continuous basis.

c. Power Factor Correction Equipment. Power factor correction of the emitter load on the power supply is sometimes necessary for the CG-1000 sound system in areas with wide variations in seasonal temperature. Adjustment of the power factor is made through changing the capacitance of the emitter circuit. Six capacitors make up the Power Factor Correction Capacitance Bank within the CG-1000 power supply cabinet. For extremely cold environments, a separate Temperature Control Power Factor Correction Cabinet, housing the six capacitors, a thermal sensor, and a switch, may be installed. This system automatically lowers the capacitance of the emitter circuit when the temperature drops below 20 degrees F, and replaces the capacitance when the temperature goes back above 20 degrees F. Refer to the CG-1000 manual for more information on power factor correction.

11. Fog Detectors. In the mid-1980's, units were provided with Videograph Model B fog detectors, which were the only approved devices for automatic switching of a sound signal. The VM 100 fog detector was developed in the mid-1990's as a replacement for the Videograph Model B. Both devices use the principle of atmospheric backscatter of light to measure the visibility for a given optical path. They consist of a light projector, a receiver, and the appropriate amplifiers and circuitry to interpret the measured backscattered light. On the Videograph Model B, the receiver and projector are aligned vertically, while on the VM 100 they are aligned horizontally. Serviceable Videograph Model B fog detectors may be retained. New installations shall use the VM 100. Fog detector site selection is very sensitive and is discussed more fully in Chapter 6 and on Standard Drawing 130104. In general, fog detectors should be used only when continuous

operation is untenable and local or remote control of the sound signal is not possible. Before installing a fog detector as a response to noise complaints, attempts should be made to reduce the SPL in sensitive areas by plugging the emitter or placing the emitter in a baffle. These procedures are described in COMDTINST M16500.3.

a. Videograph B Fog Detector. The Videograph B was delivered with the visibility alarm set for three nautical miles of visibility. This setting may be adjusted to meet local operational requirements. In noise complaint areas, it will often be necessary to set the alarm (see the Videograph B manual) to a setting that will actuate the sound signal only when actual visibility is equal to or less than the rated range of the sound signal.

   (1) A Pulse Generator, GCF-RWL-2093, was developed to assist in readjusting the visibility alarm setting and in maintenance of the Videograph B. Procedures for using it are described in the Videograph B manual. The pulse generator shall be used only by electronics personnel trained in the maintenance and repair of the fog detector.

   (2) While adjustment of the visibility alarm setting is possible, field personnel shall not tamper with calibration settings of the fog detector. This means that LIGHT GUIDE APERTURE READJUSTMENTS SHALL NOT BE MADE without a recalibration device and specific Commandant (G-TES) approval.

b. VM 100 Fog Detector. The VM 100 is delivered with the sounding point set for three nautical miles of visibility. The fog detector may be readjusted via push button operation on a manual interface card, or via an RS232 interface for sites with a remote link. The VM 100 will perform a self-check upon request, to confirm calibration, and may be recalibrated in the field by trained personnel using a calibration box designed for the device. Procedures for setting the sounding point, sound signal delay, and calibration are contained in the VM 100 manual.

c. Interconnection with Aid Equipment. Interconnection of a fog detector with other signal hardware is detailed on the standard drawing for the applicable signal (listed in Chapter 7).

d. Self-Checking Features. Both fog detectors are designed to perform self diagnostics for fail-safe operation. If the fog detector logic detects a failure, the sound signal is activated for continuous operation.

12. Audio Visual Controller and Navaid Sensor Module Miscellaneous Details.

a. Additional Functions of the Audio Visual Controller. The Audio Visual Controller has several other functions in addition to those outlined for light and sound signals. It provides the following:

(1) indication of fog detector fail-safe operation;

(2) local push-button for reset of fog detector;

(3) local push-button for reset of Navaid Sensor Module logic;

(4) an adjustable delay of up to 120 seconds in resetting the Navaid Sensor Modules after an AC power failure (allowing signals to stabilize);

(5) a circuit breaker-protected, 12VDC power distribution for all signal equipment, including ACMS, radio link, and spare circuits (all circuits are disconnected after 30 minutes to preserve power for the emergency signals).

b. Sensor Module Installation. Navaid Sensor Modules are mounted in a Navaid Sensor Module Panel, GCF-RWL-2241. The AVC supplies necessary DC power to the Navaid Sensor Modules.

c. Timing Circuit Limitations. The timing circuits on the Navaid Sensor Module check that there is signal activity (horn blast, lamp current or flash or rotation detector pulse)--ie: normal operation--within some preset length of time. Excessive activity, such as the light flashing too quickly, is not tested and consequently, will not cause an alarm. This means that the Navaid Sensor Module, and any connected monitor equipment, will confirm that a horn is sounding or light is flashing, but will not provide an alarm when the signal is flashing or sounding faster than it should. This is considered acceptable since; (1) these are not natural failure modes for any low-voltage DC electronic signal coding devices used, (2) commercial power frequency for beacon rotating motors is stable, and (3) prime/standby power generators are typically equipped with overspeed trips for output exceeding 63Hz.

C. Standard 12VDC Solar Lighthouses. Commandant (G-ECV) centrally procures and stocks standard 12VDC rotating beacons for modernization and solarization projects. Lenses for rotating beacons may be of any approved signal color, with blanking panels available to produce group characteristics.

1. Standard 12VDC Rotating Beacons. The standard 12VDC rotating beacon is the VRB-25. The VRB-25 is based on six fresnel bullseye lenses which rotate about a common focal point, producing up to six pencil beams. The lenses have a 180mm focal-length, making the dimension across the lens cage 360mm (14.2 inches).

   The rotation speed is field selectable, ranging from 0.5 to 16 rpm, with a factory-setting of one rpm. Rotation detection is sensed for each half revolution to insure an appropriately timed signal is sent to control equipment even for speeds as low as 0.5 rpm.

   The VRB-25 may be ***externally controlled,*** using the standard 12VDC control hardware described later in this chapter, or ***internally controlled*** using a flasher. When outfitted with lamps rated at 50 watt or greater, a high-wattage flasher (CG-481) should be used. The standard flasher (CG-181) is used with lower wattage lamps.

2. Other Rotating Beacons. Other optics currently in use, including the Amerace-ESNA 2130 and the APRB-251 (190mm), should be scheduled for eventual replacement with the VRB-25.

3. Non-rotating Optics. The primary omnidirectional lantern for a new solar installations is the 300mm marine signal lantern, which is commercially available. The 250mm marine signal lantern and 155mm buoy lantern may be used at sites requiring low intensity light signals. All of these lanterns use a molded acrylic fresnel lens. Selection of a lantern for installation must include an evaluation of power dissipation. The unvented version of the 250mm can only dissipate 75 watts continuous, while a vented version can dissipate up to 200 watts. The 300mm can dissipate 250 watts continuously. The 155mm lantern cannot accept any lamp larger than the 2.03A marine signal lamp.

   Classical lenses shall not be used with 12VDC marine signal lamps, due to poor coupling between the lamp and lens.

4. Lampchangers. SUPCEN Baltimore maintains a stock of the standard six-place lampchangers (CG-6P) in the supply fund. Contact Commandant (G-ECV) for information on the availability of high-wattage lampchangers (CG-6PHW) for aids using lamps rated at 50 watts or greater.

5. <u>Emergency Lights</u>. When required, emergency lights shall normally be provided by standard 12VDC omnidirectional lanterns, equipped with CG-181 flashers and CG-6P lampchangers, and lamped with standard 12VDC marine signal lamps. The emergency light should have the same characteristic as the main light. Nonstandard CG-181 flashers may be special ordered from manufacturers listed on the CG-181 Qualified Products List (QPL), maintained by Commandant (G-ECV). If there is an operational requirement for greater range than can be provided by a 12VDC omnidirectional lantern, or a requirement for an alternating characteristic, the VRB-25 may be used.

6. <u>Sound Signals</u>. The standard sound signal for a solar lighthouse is the 12VDC powered, 390Hz, omnidirectional, twin-emitter FA-232/02. The FA-232/02 generates an SPL of 128.7 dBC, for a usual audible range of one nautical mile. The horn may be plugged to make it a directional emitter. COMDTINST M16500.3 provides information on the procedure for plugging the horn. The FA-232, with an SPL of 122.7 dBC (0.5 nautical mile) may be used as the primary sound signal in areas where a reduced range is sufficient. Commandant (G-TES) periodically buys FA-232 and FA-232/02 sound signals and spare parts to maintain existing signals and provide for new installations.

7. <u>Emergency Sound Signals</u>. The standard emergency sound signal is the FA-232.

8. <u>12VDC Light Control Systems</u>. DC-powered beacons may be externally or internally controlled. External control, using a Solar Distribution Box (SDB) with a Solar Aid Controller II (SAC II), is used when there is an emergency battery, an emergency light and/or the aid is monitored. This includes Solar Category I and II Lighthouses. Internal control is performed by a flasher mounted inside the beacon. The flasher provides the lampchanging function, voltage regulation, and daylight control signals. Solar Category III Lighthouses may be controlled in either manner. The equipment discussed here is for control of the light signal itself, and is not part of the Low Energy Aid Control and Monitor System (LEACMS). It does, however, provide the inputs to the LEACMS for remote monitoring of the signal status.

   a. <u>Solar Distribution Box (SDB)</u>. The SDB selects between main and emergency batteries. There are two voltage monitoring circuits in the SDB; the first posts a low voltage alarm to the LEACMS when the main battery state of charge (SOC) drops to approximately 40 percent (11.5 volts), the second circuit activates a load transfer relay in the event of a main battery failure, or if the battery SOC drops below 20 percent (11 volts).

If the main battery fails, or reaches a 20 percent SOC, the loads, with the exception of the main light, main beacon motor and main sound signal, are switched to the emergency battery. The main light and sound signals are taken off line to extend the emergency battery service interval. When and if the main battery is recharged to 12.75 volts, the SDB will switch loads, including main light sound signals, back to the main battery.

The SDB also provides a mounting location for up to two Solar Aid Controller IIs (SAC IIs); one each for light and sound signals.

b. Solar Aid Controller II (SAC II). A SAC II is used to control and monitor the operation of DC powered aids to navigation signals. If the primary aid malfunctions, the SAC II provides a signal to indirectly control the secondary aid. In addition, if the SDB switches the loads to the emergency battery, the SAC II will note a "failure" of the main light and, after a delay of about 90 seconds, will activate the emergency beacon. The SAC II also provides daylight switching for both main and emergency lights, and transmits status signals of the light to the LEACMS, when installed.

The SAC II has two terminal strips, one at each end of the device. Terminal strip "TB1" contains ten terminals for low-current connections including SAC II power, rotation detection input, daylight control signal input, a remote reset and the status signal outputs. Terminal strip "TB2" has three terminals for high-current 12VDC power switching and lampchanger control. The SAC II uses negative-side switching.

The SAC II will usually be installed in a SDB or a Multiarray Controller (MAC). The SAC II must be mounted on a surface that will conduct heat away from it. Use thermal compound when mounting to the SDB or MAC chassis or other metal surface.

c. Equipment Interconnections. A functional diagram for a light system consisting of an SDB, SAC II, VRB-25 and emergency light is depicted in Figure 2-5. Detailed interconnection and troubleshooting drawings are included in the list of standard drawings in Chapter 7.

(1) Referring to Figure 2-5, 12VDC from the SDB is connected via the load transfer relay to the rotation motor on the VRB-25. Main light power return is routed through the SAC II. A rotation detection signal is sent from the VRB-25 to terminal TB1-4 of the SAC II. (Note; the small blue jumper wire connecting TB1-2 and TB1-3 must be removed to enable the rotation monitoring circuitry.) A Type L daylight control is wired to TB1-5 and TB1-2. An Auxiliary Reset Module (ARM) controls transmission of F-Pulse signals from the SAC II to the main light lampchanger.

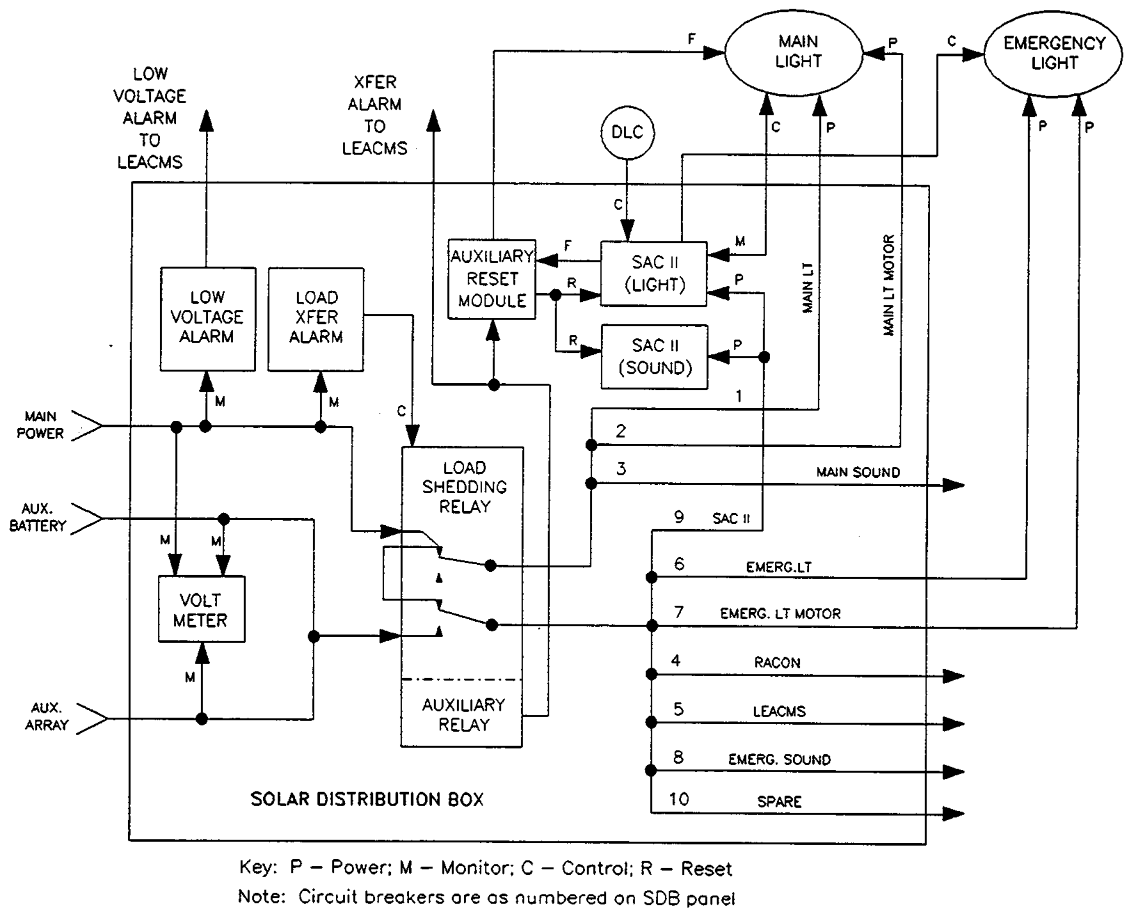


Figure 2-5
Interconnection Diagram for Light Signal and Control Equipment Solar Category I or II Light (Rotating Main Light)

(2) The SAC II provides two signal status outputs for the main light; primary mode (**NORMAL** or **FAIL**) and primary status (**ON** or **OFF**). Primary mode **NORMAL**

is an indication that the rotation detector is sending a ground pulse to the SAC II every 20 to 90 seconds, and that the main light has not burned out all available lamps. Primary mode **FAIL** indicates that the SAC II failed to receive a ground pulse within 90 seconds of the previous pulse, or that the final lamp in the optic has burned out. At that time, the SAC II will secure power to the main light and apply a ground to the "S" terminal adjacent to the "+" terminal on the CG-181 flasher in the emergency beacon, thereby activating the emergency beacon. Note; the two "S" terminals on the CG-181 flasher must be tied together with a 6.8kΩ resistor.

(3) A primary status **ON** signal is generated when the daylight control resistance rises, and ground is removed from TB1-5. At that point, the SAC II high current power port (TB2-1 & 2), which is an open-drain MOSFET power switch, will close, allowing current to flow to the main beacon lamp. The SAC II senses lamp current within the power port. If lamp current loss is detected while the power switch is closed, an F-function signal is applied from TB2-3 to the main beacon lampchanger "F" terminal, advancing the lampchanger to the next lamp. When the last lamp in the main beacon lampchanger burns out, the SAC II will continue to apply the F-function signal until its internal timer expires (approximately 90 seconds). The SAC II will then change to auxiliary mode of operation, securing power to the main light at the power port and applying a ground from TB1-10, via a diode, to the "S" terminal adjacent to the "+" terminal on the CG-181 flasher in the emergency light, and post a primary mode **FAIL** to the LEACMS.

(4) A logic "low" at TB1-9 indicates an **AUXILIARY MODE** status. After the SAC II enables the emergency light, the main light daylight control will control the emergency light operation by toggling the status at TB1-10 between logic "low" for **AUXILIARY ON** and "float" for **AUXILIARY OFF.** In auxiliary mode the CG-181 flasher in the emergency beacon will provide lamp current monitoring and lampchanging.

(5) Ensure that an Auxiliary Reset Module (ARM) is installed in SDBs with serial numbers beginning with the letters A, B, or C (e.g. A04, C12). The ARM performs two functions: It interrupts transmission of the F-Pulse from the SAC II to the main light lampchanger in the event that the

system transfers to auxiliary battery power; and secondly, provides a system reset ground pulse to the SAC IIs when the main battery comes back on line. Subsequent systems will have the ARM built-in, and field installation will not be required.

d. Multiarray Controller (MAC). A MAC may be used in place of the SDB to provide switching of loads from the main to the emergency battery at solar powered sites with arrays of 525 watts or less. SAC IIs are installed to monitor and control the signals, in a similar manner to the SDB/SAC II combination discussed previously.

The MAC ties the loads, solar arrays, batteries, and SAC IIs together. The main solar array is connected to the MAC at array input terminals labeled "A" through "E," while the auxiliary array is connected to the "F" terminals. 12VDC power is distributed to the loads through eight independent circuits.

There are two battery voltage monitoring circuits in the MAC. When main battery SOC falls to 40 percent (11.5 volts), the MAC will post a low voltage alarm to the LEACMS. When SOC reaches 20% (11.0 volts), the MAC transfers ALL loads to the auxiliary battery. When and if the main battery is recharged to 12.75 volts, the MAC will switch loads from the emergency battery back to the main battery.

With a MAC, all loads operate off the same battery. In the event of a main battery failure, the loads, including main light and sound, will be transferred to the auxiliary battery. AS THE AUXILIARY BATTERY CAPACITY IS SMALL, COMPARED TO THE MAIN BATTERY, THE AUXILIARY BATTERY MAY BE DEPLETED IN A SHORT PERIOD OF TIME BY THE MAIN SIGNALS. For this reason, the SDB will generally be preferred for new solar powered installations.

e. CG-181/CG-481 Flashers. The CG-181 and CG-481 flashers are used for internal control of flashed 12VDC signals, at aids where there is no emergency light and the aid is not monitored. The CG-481 is used with lamps rated for 50 watts or more. Flashers with a fixed-characteristic may be used for internal control of rotating 12VDC beacons.

f. Daylight Control. All aids using solar power should be daylight controlled, so as to conserve battery power. A Type L daylight control is used with rotating beacons. For the omnidirectional beacons, a Type C daylight control is used with clear or yellow lens, while a Type R is used with red or green lens.

9. Sound Signal Control Systems. FA-232 sound signals have integrated timer cards, and can be connected directly to power without auxiliary control equipment. However, if the sound signal must be remotely monitored or is backed up by an emergency sound signal, an SDB (or MAC) and SAC II are required. The same SDB as that controlling the main and emergency light may be used, as it provides mounting and connections for both a SAC II to control the light and a SAC II for sound signal control.

a. Primary Sound Signal. Operation of an FA-232/02, with an emergency sound signal, SDB, and SAC II, is shown in Figure 2-6. In general, fog detectors will not be used at solar powered aids, due to their large power demands. Detailed interconnection and troubleshooting drawings for this and similar systems are listed in Chapter 7. The 12VDC power for the sound signal comes from the SDB, via the negative-side switching power port (TB2) in the SAC II.

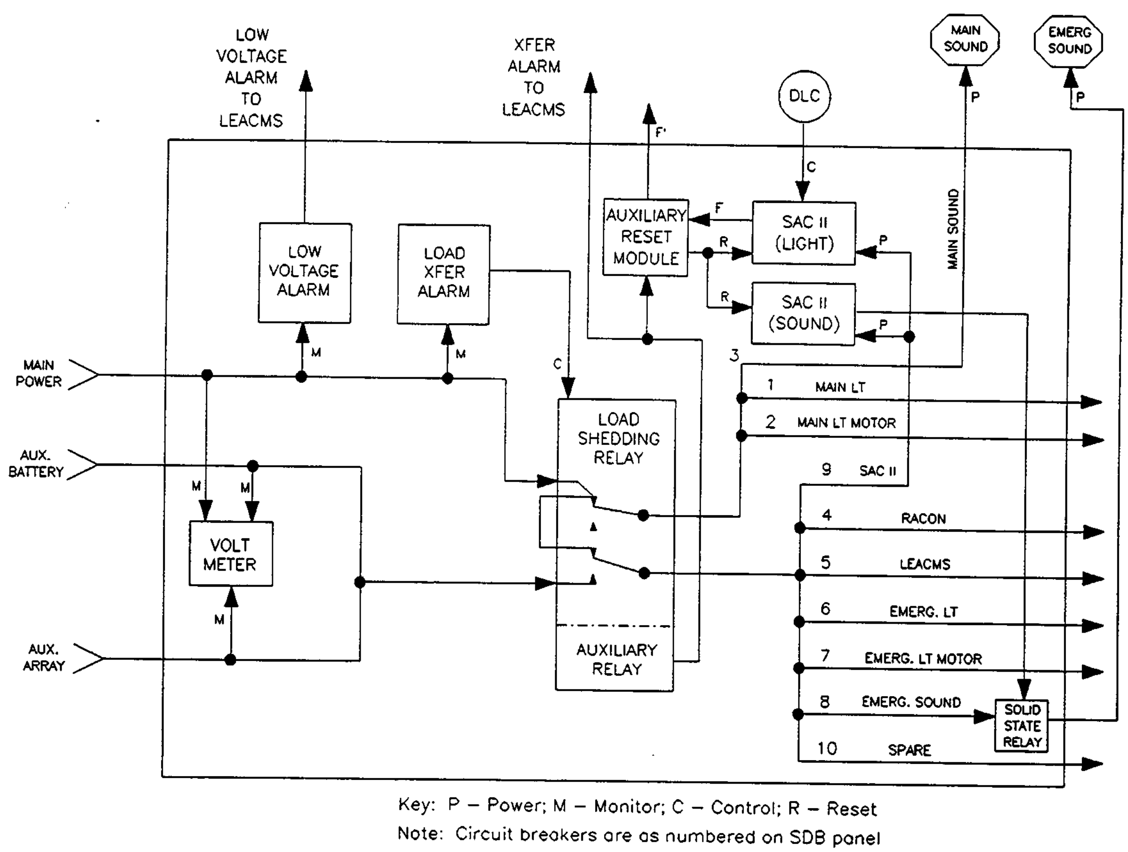


Figure 2-6
Interconnection Diagram for Sound Signal and Control Equipment
Solar Category I or II Light
(12VDC Primary Sound Signal)

10. Fog Detectors. Fog detectors and their applications are described in detail in paragraph 2.B.11. Fog detectors can be used to control sound signals at solar powered aids, but their use will increase the required size of the solar array by several panels, and the size of the battery by several hundred amp-hours. For load profile data, contact Commandant (G-ECV) or (G-TES).

11. Solar Distribution Box and Solar Aid Controller II Miscellaneous Details.

a. Additional Functions of the Solar Distribution Box. The SDB has several other functions in addition to those outlined for light and sound signals. It also provides the following:

(1) Circuit breaker-protected power for all light and sound signals, SAC IIs, and for a RACON and LEACMS, if so equipped;

(2) Blocking diode for auxiliary solar panel array;

(3) Built in voltmeter, with a three-position switch, to measure voltage at the main battery, auxiliary battery, or the auxiliary array;

(4) LED visual indicators for the Low Battery Alarm and Load Transfer Alarm (voltage monitoring circuits); and

(5) Adjustable trip points for the voltage monitoring circuits.

b. Solar Aid Controller II Installation. SAC IIs are generally mounted inside the SDB (or MAC) chassis. Power for the SAC IIs, and all 12VDC loads, is supplied via the SDB circuit breakers.

c. Solar Aid Controller II Switch (S1). The SAC II has a small two-position switch, marked S1 or SW1. This switch selects whether the load at the power port (TB2-1) is a primary or auxiliary aid. The SAC II is used almost exclusively with S1 in the "1" position. With S1 in the "1" position, the SAC II considers the load at TB2-1 as a primary (main) signal and operates and monitors the current and rotation of the load in the primary mode. With S1 in the "2" position, the SAC II considers the load at TB2-1 as an auxiliary signal, and operates the signal accordingly. In this position, the SAC II monitors the auxiliary signal current only. A lampchanging signal (F-pulse) is available to the signal in both modes.

The SAC II is used with switch S1 in position "2" mainly in situations where the primary signal cannot be directly controlled by the SAC II at TB2. For instance, when the primary signal is powered by 120VAC. In this situation, the 12VDC auxiliary signal is controlled through the SAC II power port (TB2) when activated (90 seconds after failure of the primary signal), while the 120VAC primary signal is indirectly monitored through the rotation detection input (TB1-4). UNDER NO CIRCUMSTANCE SHOULD 120VAC BE APPLIED TO ANY TERMINAL OF THE SAC II.

d. Solar Aid Controller II Reset. The SAC II may be reset by applying a momentary ground to the reset terminal, TB1-6, or by breaking the contact to the SAC II power input terminal, TB1-1, for 15 seconds. Applying ground to the reset terminal may be done manually, or by a remote LEACMS reset command.

D. Ranges - General. Selection of the appropriate category for a range should be made in accordance with the guidelines outlined in Chapter 1 of this manual. Ranges may have both daytime and nighttime optics, or nighttime optics alone, which may or may not be daylight controlled. While the following discussion of standard ranges implies that similar systems are used on both front and rear towers, in fact, the power systems and optics may be different. For instance, a large day/night range may have 120VAC optics for the daytime signal and 12VDC optics for the nighttime signal on the rear tower, with 12VDC optics for both daytime and nighttime signals on the front tower. In this example, the front tower lights may be powered from 120VAC, via an AC/DC converter, or by solar power. The selection of appropriate signal and power equipment should be based on the light intensity required and the availability of reliable commercial power.

E. Standard 120VAC Ranges. Commandant (G-ECV) centrally procures and stocks 24 inch (RL24) and 14 inch (RL14) directional range lanterns for use in waterways projects. Omnidirectional 250mm and 300mm lanterns, with and without condensing panels, are also used on 120VAC powered ranges. Other signaling systems, such as extended light sources, directional lights, or alternative lighting technologies, are not discussed in this manual. Information regarding these systems may be obtained from Commandant (G-ECV).

This section specifically discusses the optics and control equipment used with AC power. The range may have day and night optics, or night optics only, and may use 12VDC power for one or more signals. Selection of the appropriate range category should be made in accordance with the guidelines established in Chapter 1.

1. Standard 120VAC Directional Range Lanterns.

   a. 24 Inch Range Lanterns. The RL24 uses the same optic as the DCB24/224 Rotating Beacons, and comes equipped with the CG-2P lampchanger. The RL24 should be outfitted with 1000 watt, mogul-bipost lamps. These range lanterns can be equipped with filters of any approved signal color.

   b. 14 Inch Range Lantern. The RL14 optic uses a 14 inch, deep-dish parabolic mirror to generate a highly collimated pencil beam. The RL14 may be equipped for either 120VAC or 12VDC operation. In AC-applications the RL14 is equipped with a four-place lampchanger (CG-4P), outfitted with either 150 watt or 250 watt DC-bayonet mount lamps. The CG-4P is commercially available. A more extensive discussion of the RL14 may be found in Section F, below.

2. Other Directional Range Lanterns. The 250mm and 300mm omnidirectional lanterns may be considered quasi-directional with the addition of condensing panels.

3. Standard 120VAC Omnidirectional Range Lanterns. The primary omnidirectional lanterns for new installations are the 250mm and 300mm marine signal lanterns. As with lighthouse applications, selection of the appropriate lantern must include an evaluation of required power dissipation. The unvented version of the 250mm can only dissipate 75 watts, while a vented version can dissipate up to 200 watts. The 300mm can dissipate 250 watts continuously. For AC-applications, only the 250W lamp should be used in these lanterns.

   Non-rotating classical lenses should be retained if serviceable. Any modification or replacement of a classical lens must be coordinated with the appropriate historic preservation interests.

4. Emergency Range Lanterns. When required, emergency range lanterns should normally be provided by 12VDC powered range lanterns, equipped with CG-181 flashers and CG-6P lampchangers, and outfitted with 12VDC lamps. The emergency lantern should have the same characteristic as the primary range lantern. Range Category I and Solar Range Category I systems may employ the nighttime range lanterns as the emergency lights for the daytime optics. In this case, a third set of range lanterns may be used to backup the nighttime optics. UNDER NO CIRCUMSTANCES SHOULD DAYTIME OPTICS BE USED TO BACKUP NIGHTTIME OPTICS.

5. Sound Signals. Sound signals are not normally used on range towers. If required, however, the standard sound signals prescribed for lighthouses may be used.

6. Range Control Systems. There are two basic 120VAC range control systems; one for Range Category I equipment, which has both daytime and nighttime optics, and a second, simplified control system for Range Category II equipment.

   a. Range Category I Control System. The Range Light Controller (RLC), GCF-W-1201-RLC, is used at Range Category I aids to control the range lanterns. A complete system is made up of two RLCs, one on each range tower. A single RLC consists of two fiberglass NEMA enclosures; one for the Control Unit, and one for the Power Unit. Each RLC can support up to four daytime optics, two primary nighttime optics, and one secondary nighttime optic. The RLC uses a Type L daylight control.

The RLCs communicate via a radio/modem to synchronize front and rear day/night mode switching. The RLCs also permit synchronization of front and rear flash rhythms. RLCs will support fixed or flashing characteristics at one or both towers.

The RLC can operate as an ACMS Remote Unit, and can communicate with the ACMS Master Unit via radio link, direct telephone, or cellular telephone. One of the two RLCs in a Range Category I aid is designated the master, and exchanges status and control information with the ACMS Master Unit, if monitored.

b. Range Category I Equipment Interconnections. The wiring diagram for a RLC, 120VAC daytime and primary nighttime optics, and 12VDC secondary (emergency) nighttime optics, is depicted in Figure 2-7. Many of the system components are omitted to simplify the diagram. Detailed interconnection drawings are included in the list of standard drawings found in Chapter 7. Detailed circuit and logic explanations are included in the RLC manual which is shipped with the unit.

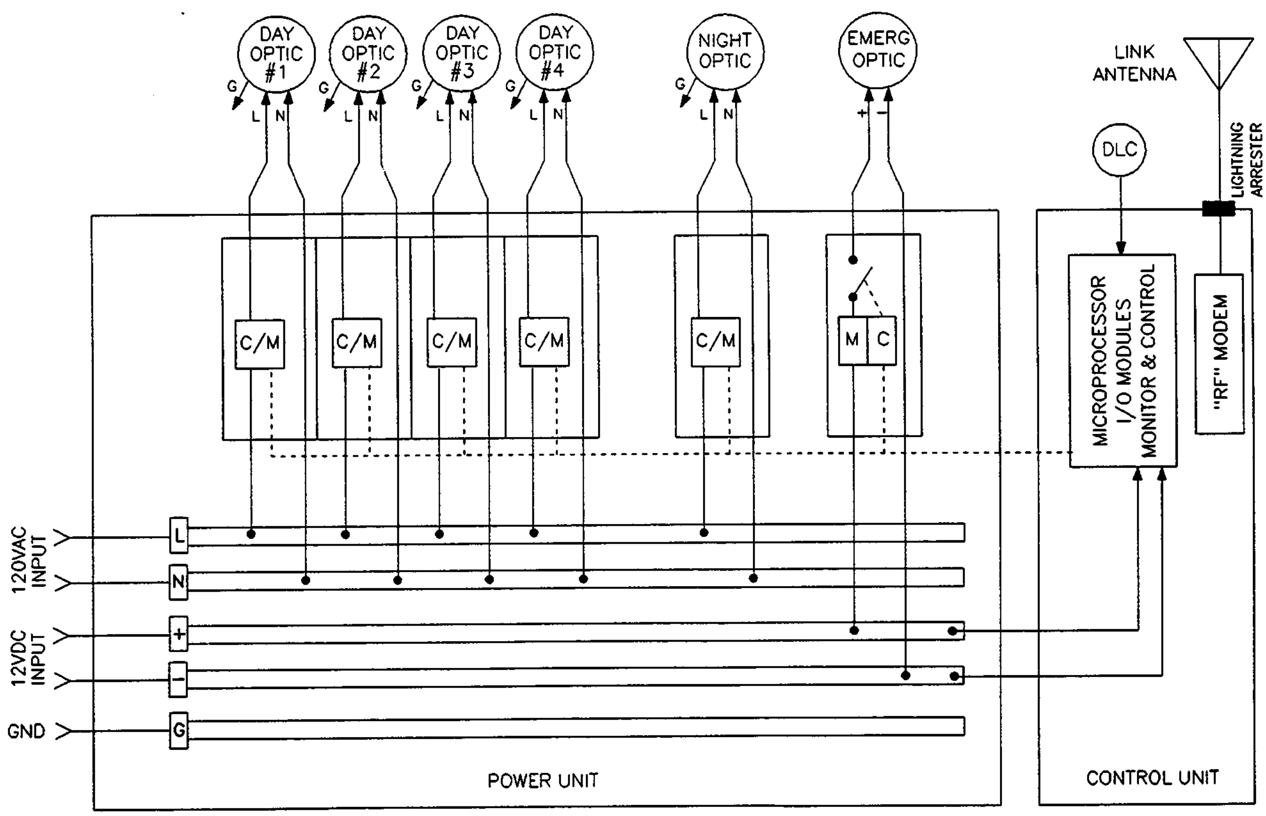


Figure 2-7
Interconnection Diagram for Range Light Controller
Range Category I

c. Range Category II Control Systems. The control system at a Range Category II aid employs either an AC Flash Controller or a FLAC-300 to flash and/or provide daylight control switching of the range lanterns. Daylight control switching at the front and rear towers are not synchronized, nor can the flash rhythms be synchronized. Installation of an emergency optic would require adding an Audio Visual Controller (AVC) with a Navaid Sensor Module, as described in Section B above, to the control system.

(1) AC Flash Controller. The AC Flash Controller is described in the discussion on 120VAC Light Control Systems, on page 2-7. It will normally be used for range lanterns outfitted with the 1000 watt lamp, such as the RL24 and some classical lenses and 300mm lanterns.

(2) FLAC-300. The FLAC-300 is described in the discussion on 120VAC Light Control Systems, on page 2-8. It will normally be used in range lanterns outfitted with either the 150 watt or 250 watt lamps, such as the RL14, the 250mm lantern, the majority of 300mm lanterns, and a limited number of classical lenses.

d. Daylight Control. Range Category I must be daylight controlled, in order to switch between daytime and nighttime optics. Range Category II aids may be operated continuously, to simplify the system, or may be daylight controlled to extend the service life of the lamps.

F. Standard 12VDC Solar Ranges. Commandant (G-ECV) centrally procures and stocks 14 inch (RL14) directional range lanterns for use in waterways projects. Omnidirectional 250mm and 300mm lanterns, with and without condensing panels, are also used on 12VDC powered ranges. Other signaling systems, such as extended light sources, directional lights, or alternative lighting technologies, are not discussed in this manual. Information regarding these systems may be obtained from Commandant (G-ECV).

This section specifically discusses the optics and control equipment used with DC power. The range may have day and night optics, or night optics only. Selection of the appropriate range category should be made in accordance with the guidelines established in Chapter 1.

1. Standard 12VDC Directional Range Lanterns. The standard 12VDC directional range lantern is the 14 inch range lantern (RL14). There are two versions of RL14 range lanterns in service; the RL-10668 and the RL-355. These are the manufacturers' designations, which will only be cited for positive identification of an optic. Only the RL-10668, or other RL14s built to the same design, are approved for new installations.

   The RL14 optic uses a 14 inch, deep-dish parabolic mirror to generate a highly collimated pencil beam. The primary differences between the two versions of this optic are that the RL-10668 uses a metal mirror and has several machined surfaces to insure metal-to-metal contact at all key interfaces, while the RL-355 uses a glass mirror and does not have metal-to-metal contact at the junction between the bezel assembly (door) and the drum. Serviceable RL-355 range lanterns may be retained in service, but should be replaced if the mirror is broken or the optic is otherwise damaged.

   For DC applications, the RL14 is equipped with the CG-6P lampchanger, and can be outfitted with a wide variety of 12VDC lamps. These include all the standard marine signal lamps, a series of CC-8 filament lamps, and a series of tungsten-halogen lamps, up to and including the 12VDC 110 watt lamp. The CG-6PHW, high-wattage version of the six-place lampchanger, should be used with any 12VDC lamp rated at 50 watts or more.

   The RL14 can be equipped with filters of any approved signal color, and with a series of spread lenses. A spread lens must be used with the standard 12VDC marine signal lamps (ie: the 0.25A to 3.05A lamps), due to the potential for beam wander. The CC-8 filament lamps and tungsten-halogen lamps may be used with or without spread lenses.

2. Other Directional Range Lanterns. The FA-240 range lantern remains in widespread use. While this optic does not produce the same intensity as the RL14, and requires that lamps be hand-selected for proper focus, serviceable FA-240 range lanterns should remain in service. New installations and replacement of damaged optics, however, should use the RL14 or omnidirectional optics. The 250mm and 300mm omnidirectional lanterns may be considered quasi-directional with the addition of condensing panels.

3. Standard 12VDC Omnidirectional Range Lanterns. The primary omnidirectional range lanterns for new installations are the 250mm and 300mm marine signal lanterns. The unvented version of the 250mm lantern can only dissipate 75 watts continuously. Therefore, 100 watt and 110 watt tungsten-halogen lamps cannot be burned fixed-on in this optic.

   In some limited cases, the 155mm buoy lantern may make an acceptable range lantern. The 155mm lantern cannot accept lamps with bulbs larger than the S-8 bulbs found on the 12VDC, 0.25A to 2.03A, marine signal lamps.

   The CC-8 filament, and tungsten-halogen lamps smaller than 100 watts should not normally be used in the omnidirectional range lanterns, as the relatively short filaments will result in a reduced vertical divergence of the light output.

   Classical lenses should not be used with 12VDC lamps, due to poor coupling between the light source and the lens.

4. Emergency Range Lanterns. When required, emergency lights shall normally be provided by RL14 range lanterns, due to the ability of this lantern to provide the greatest light output for the smallest lamp size. The emergency lantern should have the same characteristic as the primary range lantern. Solar Range Category I systems may employ the primary nighttime range lanterns as the emergency lights for the daytime optics, with a secondary nighttime optic as backup for the nighttime signal. UNDER NO CIRCUMSTANCES SHOULD DAYTIME OPTICS BE USED TO BACKUP NIGHTTIME OPTICS.

5. Sound Signals. Sound signals are not normally used on range towers. If required, however, the standard sound signals prescribed for lighthouses may be used.

6. Solar Range Control Systems. There are two basic 12VDC range control systems; one for Solar Range Category I equipment, which has both daytime and nighttime optics, and a simplified system for Solar Range Category II equipment.

a. Solar Range Category I Control System. The Range Light Controller (RLC), GCF-W-1201-RLC, used at Range Category I aids, is also used to control the range lanterns at Solar Range Category I aids. The functions of the RLC are described in Section D, above.

b. Solar Range Category I Equipment Interconnections. The wiring diagram for a RLC and 12VDC range lanterns (daytime, primary nighttime and secondary nighttime) is depicted in Figure 2-8. Several system components are omitted for clarity. Detailed interconnection drawings are included in the list of standard drawings found in Chapter 7. Detailed circuit and logic explanations are included in the RLC manual which is shipped with the unit.

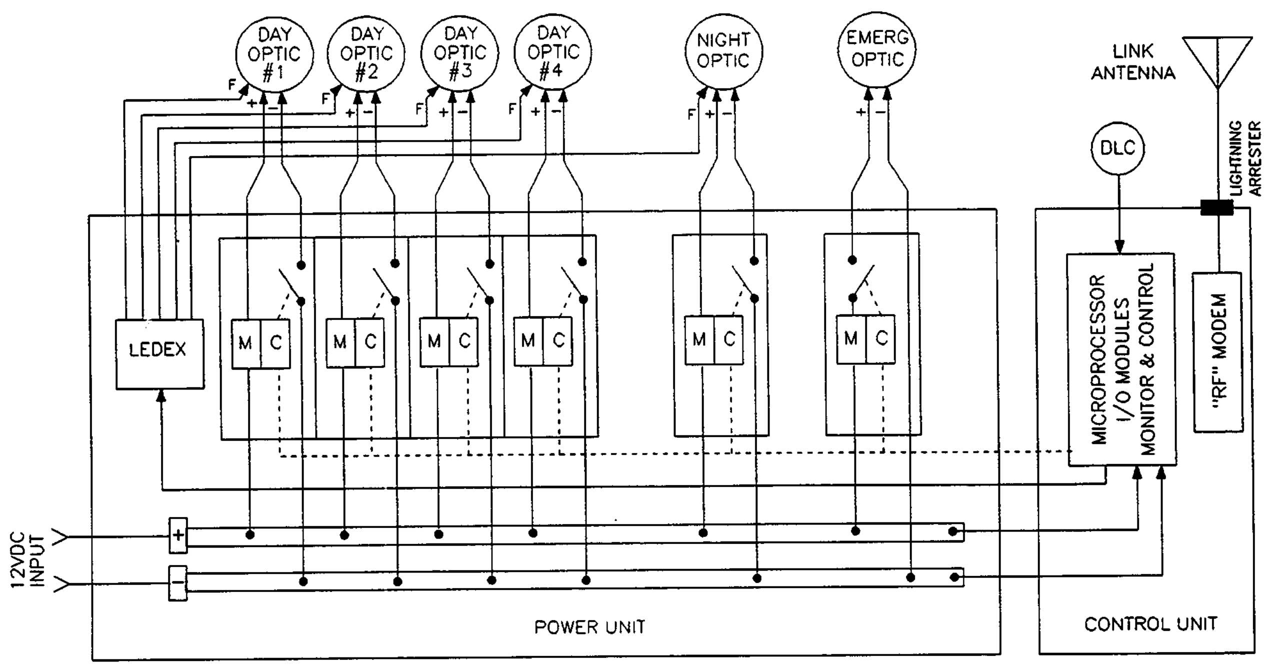


Figure 2-8
Interconnection Diagram for Range Light Controller
Solar Range Category I

c. Solar Range Category II Control Systems. The control system at a Solar Range Category II aid employs the Multiarray Controller (MAC) to tie the loads, solar arrays, batteries and Solar Array Controller IIs (SAC IIs) together. Daylight control switching of the front and rear towers is not synchronized, nor can the flash rhythms be synchronized. This control system will support emergency optics.

7. <u>Daylight Control</u>. Both Solar Range Category I and Solar Range Category II aids should be daylight controlled. At a Solar Range Category I aid, the daylight control signal is used to switch between daytime and nighttime optics. At Solar Range Category II aids, the range lanterns are secured during daylight hours to conserve power and extend the service life of the lamps.

CHAPTER 3. POWER SYSTEMS

A. General. Electrical power systems on major aids have a primary influence on signal reliability. Therefore, power system selection, design and maintenance for modernized or solarized aids is important. The purpose of this chapter is to promulgate electrical power system standards for major aids by comprehensive discussions on all significant areas of power system design, installation and support. These discussions contain engineering policy, standard and special purpose equipment descriptions, alternatives, requirements, suggestions and recommendations.

B. Power System Choice. The decision on which power source to use for aids to navigation should be accomplished by an engineering economic analysis conducted per NAVFAC P-442 Economic Analysis Handbook and as outlined later in this chapter.

1. Shore Aids - Commercial Power. The preferred power source for an aid to navigation is commercial power. Generally, the reliability and economy of this power source cannot be matched by any alternative system.

a. Availability. The availability of commercial power must be measured in order to determine if a backup power source is required. A power utility that experiences many failures, but corrects them in seconds is more desirable than a utility that experiences few failures, but takes days to repair. In general, if a utility has power availability of greater than or equal to 99.9 percent, no backup power is required unless the aid is determined by the program manager to be highly sensitive. Power availability is calculated by:

$$\text{Availability}(\%) = \frac{100\ \text{MTBF}}{(\text{MTBF} + \text{MTTR})}$$

Where:

MTBF is the mean time between failures;
MTTR is the mean time to repair (units same as MTBF).

To determine MTBF and MTTR, District Offices and Civil Engineering Units (CEUs) should study light station logs and utility company records. The time and duration of outages should be tabulated for at least three years, if possible. Where such historical data cannot be obtained, a data recorder, available through most electronic equipment rental centers, should be installed at the intended point of service for 6-12 months to obtain meaningful data.

b. Accessibility. If the aid is commercially powered, but significant lengths of feeders are buried or where overhead wires are not readily accessible, AC backup power should be provided. Outages at these sites will typically exceed the standby battery autonomy, necessitating backup power.

2. Shore Aids - Commercial Power, AC Backup Power Required. The backup power source may be either a permanently installed, standardized, high endurance, standby diesel engine-generator or a portable emergency diesel engine-generator, depending on the sensitivity of the aid. The permanently installed unit should be equipped with an electronic Lighthouse Power Controller (LPC) furnished by Commandant (G-ECV-3). Specifications for standard engine-generator sets are available from Commandant (G-ECV-3). The project documents should discuss the sensitivity of the aid, as determined by the program manager, when proposing a backup power source for a commercially powered aid:

a. High Sensitivity. If any of the AC powered signals at an aid have critical sensitivity in the area AtoN system, such that an outage due to commercial power failure seriously reduces the mariner's ability to navigate safely, the site should be equipped with a permanently installed, automatic standby engine-generator.

b. Low Sensitivity. If all of the AC powered signals at an aid are of low sensitivity in the area AtoN system, a permanently installed emergency power entrance assembly, consisting of a receptacle and manual transfer switch, should be provided for safe connection of a portable, emergency engine-generator. The emergency engine-generator should be procured as a commercially available unit. Selection assistance is available from Commandant (G-ECV-3). The suggested receptacle and mating plug is a Crouse-Hinds Company Model RPC-733-006-S12AT and RPC-533-153-P12AT (check compatibility with commercial power units). The suggested transfer switch is an OEM Controls, Inc., Model VN1000-2 series (call for specific application). Refer to Standard Drawing 130914 for construction of the entrance assembly. The portable generator should be equipped with a cable assembly of sufficient length for convenient deployment.

3. Shore Aids - Retention of Standby Engine-Generators. An existing automatic and permanently installed standby diesel generator on a shore aid may be retained, regardless of the aid category, if the CEU can provide support for the foreseeable future. However, the generator should be inspected and operated to ensure

operational readiness, proper automatic start-up and shutdown sequence (time delay on load transfer, time delay on transfer to commercial), and satisfactory voltage and frequency regulation. The generator should have, or be equipped with, engine and load protective devices and should be interfaced with the Aid Control Monitor System (ACMS), if equipped. The minimum engine protective devices are low lube oil pressure, high engine temperature, and overspeed. The minimum load protection devices are under-frequency and over-voltage with time delays. Any generator that requires upgrade modifications or repairs exceeding 50 percent of the acquisition cost of a new unit, should be replaced. The project documents should address the above considerations if retention of an existing unit is proposed.

4. <u>Shore Aids - Replacement Standby Engine-Generators</u>. Replacement of nonstandard engine-generators should be made at the end of their useful life or when they cannot be supported. They should be replaced with standard, high endurance, permanently installed engine-generators. Specifications for standard engine-generator sets are available from Commandant (G-ECV-3).

5. <u>Shore Aids - Solar Power</u>. An aid with reduced signal capacity, i.e., 22 mile (nominal) light, 2 mile sound signal, maximum, and 15 mile racon may be powered with a solar power system. This should not preclude the use of commercial power, if available and reliable. Aids considered for conversion to solar power must satisfy the criteria set forth in Figure 3-1.

   a. The computer program SolarCalc should be used to determine array and battery size in order to determine if current available hardware exists to power the aid. A copy of the printout should be provided in the project documents.

   b. A site survey is required to determine whether the array can be installed to facilitate servicing, protection from vandalism and protection against shading. Transportation of the batteries to the aid and an adequate shelter, with emphasis on floor loading capabilities, is required as the cells (battery) used in these systems are extremely heavy. Consult manufacturers literature for physical characteristics of battery systems.

   c. The State Historic Preservation Officer (SHPO) should be notified of the intent to install a solar array and conversion or removal of the current optic to solar power. Solar arrays generally take up a lot of space and will change the visage of an aid site.

CRITERIA FOR CONVERTING 120VAC A/N POWER TO SOLAR POWER

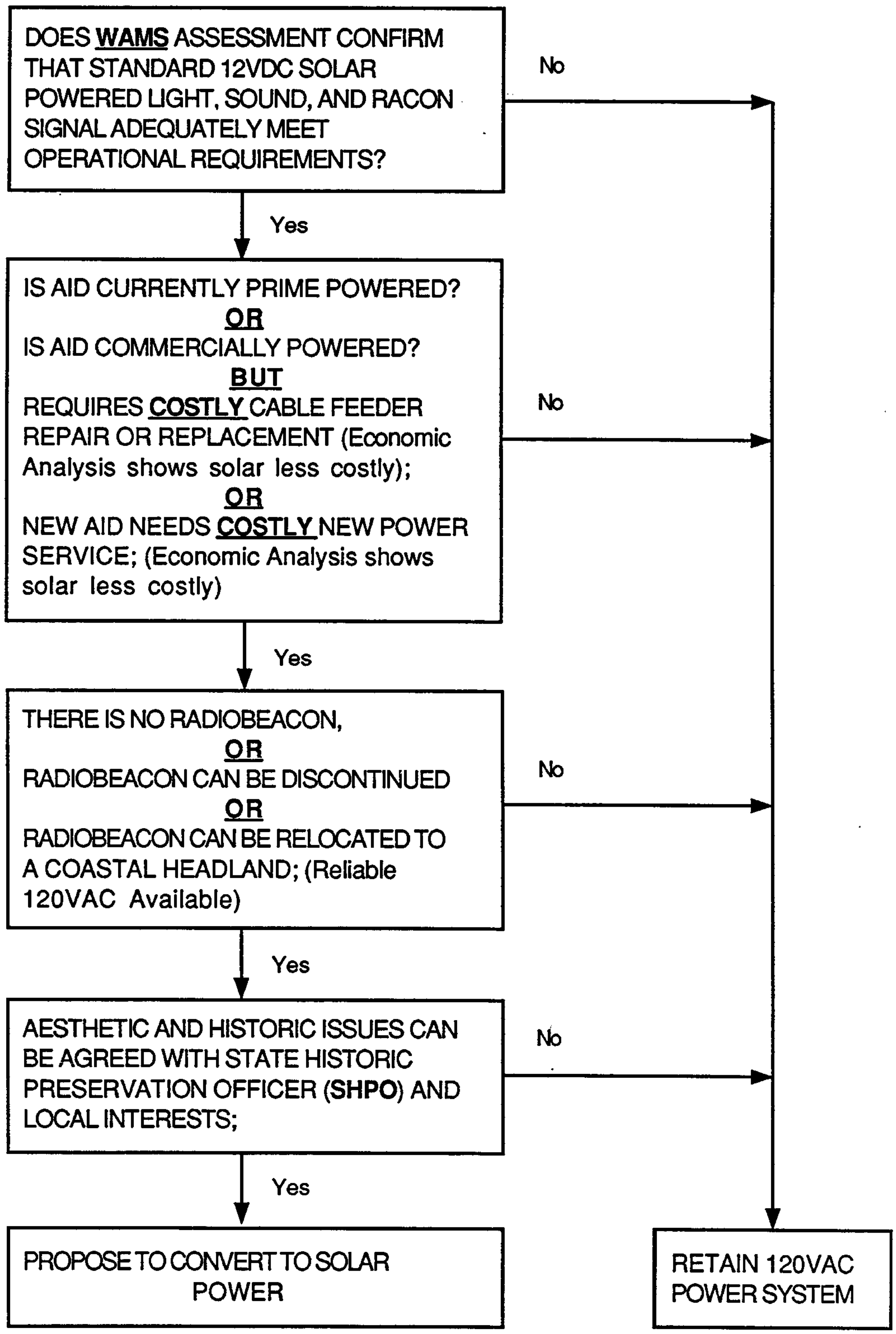


FIGURE 3-1
CRITERIA FOR CONVERTING A LIGHTHOUSE TO SOLAR POWER

6. Offshore Aids - Submarine Cable. A submarine cable is a Coast Guard owned and maintained high-voltage extension of the utility company's distribution system. It is generally vulnerable to damage from the forces of nature, and ship and boat anchors. Repair can often take weeks due to inherent contracting delays, difficulties in fault finding and complexities of cable splicing. CEUs must first determine if the capabilities exist in the district to install and maintain a submarine cable.

   a. CEUs should develop contingency emergency repair plans for each high-voltage submarine cable installed. Responsible parties for the various steps of repair (such as trained high voltage technicians to locate and repair faults, and AtoN personnel to check aid operation), location of necessary equipment and spare cable and other applicable information should be included. The mechanical design must include adequate cable termination protection from ice damage, vandalism, and the action of the sea on exposed ends. Shore ends of cable must be either protected or buried sufficiently deep to prevent inadvertent contact by the public, especially at public beaches.

   b. In areas where bottom laid cables may be susceptible to damage from anchors, consideration should be given to trenching the cable into the bottom if conditions permit. A special survey may be required for this determination. If trenching is considered, plans should be formulated to facilitate repairs in event of failure in the trenched portion. Buried cable repairs often tend to be 3 to 5 times more expensive than bottom laid cables. Also, local charts should be updated to reflect the path of the cable and signage erected at entry points to the water warning of the cable crossing.

   c. A shore end and remote site plan survey is required for all proposed cable installations where commercial power is not currently available. This survey, usually conducted in conjunction with the premodernization survey described in Chapter 6, consists of an investigation of shore and remote terrain, utility power accessibility, property right-of-way, and other possible areas of concern. A bottom survey, consisting of contouring the sea or lake bottom using electronic sounders or divers, should be made if charted information is inadequate.

   d. From the site survey and related investigations, details concerning cable length, cable route, bottom conditions, local usage of waters by fishermen, and power utility takeoff point can be assembled into a cable installation plan. The services of other Government agencies or a qualified commercial firm may be used to evaluate and coordinate cable installations. Factors such as staging areas, rights of way, environmental impact, and best time of year for installation must be included in the installation plan.

e. An initial supply of spare cable equal to 10 percent of the installed length should be procured at the same time, if it is not already on hand. For OE modernization, cable and installation costs are chargeable to AFC-43 per COMDTINST M7100.3, Manual of Budgetary Administration (USCG).

f. All aids equipped with submarine cable should be equipped with either provisions for an emergency engine-generator or a permanently installed, automatic diesel engine-generator backup with an electronic lighthouse power controller. Retention of an existing engine-generator is permitted, however sections 4 and 5 of this chapter apply.

7. Offshore Aids - Prime Power. Offshore aids equipped with large signal packages, i.e., DCB224 rotating beacon, CG-1000 sound signal and radiobeacon, and which can not be powered by submarine cable, are candidates for prime power. The prime power system consists of two standardized, high endurance diesel engine-generators equipped with an electronic Lighthouse Power Controller (LPC). This setup is the costliest to install and maintain, therefore efforts should be made to either power the aids by submarine cable or, if possible, investigate reduction of the signal requirements to allow the use of signals compatible with solar power systems.

8. Offshore Aids - Solar Power. An aid with reduced signal capacity, i.e., 22 mile light, 2 mile sound signal, maximum, and 15 mile racon may be powered with a solar power system. This should not preclude the use of commercial power via submarine cable, if available and reliable. The notes detailed in part B-5 apply.

C. Economic Analysis for the Selection of Power Source. An economic analysis should be conducted to assist in the selection of the best method of providing power to an aid. NAVFAC P-442 mandates that cost comparisons of alternatives be made using the present value of the projected total system cost over it's entire life, using the current discount rate (7% at the time of publication). For convenience, this tabulation is reproduced as Table 3-1. The prescribed discount rate is determined by the Office of Management and Budget (OMB) and is promulgated by Commandant (G-CPP). The use of the 7 percent discount rate makes allowance for cost escalation due to normal inflation. If the economic lives of alternatives under consideration are unequal, a valid comparison can still be made by calculating the equivalent uniform annual cost.

1. Determination of Service Life of Power Systems.

    a. The service life of engine-generators should be based on District experience, otherwise a minimum economic service life of 15 years can be used.

    b. The service life of submarine cable must be based on District experience in the area where the cable is installed. District cable maintenance records should allow a study to be conducted on when each cable run in the area was replaced or repaired to determine the service life estimate.

    c. The service life of large photovoltaic systems is not known. Estimates are based on manufacturers predictions and experience to date. For comparisons, allow 20 years for solar panels and 10 years for batteries.

2. Determination of Average Annual Maintenance Cost and Net Present Value. The cost estimating form for power system average annual maintenance (Figure 3-7) is provided to assist in identifying and evaluating annual maintenance costs of alternative power system. Input to this form must be based on the District's operating experience in the area under consideration. The present value analysis for a solar power system (Figure 3-8) assists in developing the Net Present Value (NPV) and equivalent Uniform Annual Cost (UAC) for solar power systems. Similarly, the present value analysis for submarine cable power systems (Figure 3-9) and prime power systems (Figure 3-10) assists in developing NPV and UAC for these systems. For systems with equal economic lives, the NPV of each can be directly compared. For systems with unequal economic lives, the equivalent uniform annual costs can be compared to assist in determining which system is preferred. Figures 3-11 through 3-16 are completed samples of the maintenance cost and present value analysis forms for two fictitious lights.

3. Additional Considerations. Engineering decisions are not based solely on cost; for each alternative there are often benefits or problems which are difficult to quantify. One major intangible in the evaluation is the ultimate energy requirement at the aid, as compared to the flexibility and salvage value of the selected method of providing power. For example, submarine cable in typical installations is capable of delivering well over a 3.5 to 10 kw required for automated aids (implying the

capability paid for but never consumed); and, while one may expect a cable to have a long service life, once it is installed at one site, it's removal and reuse at another site is impractical. A Coast Guard standard engine-generator system, on the other hand, is easily removed and refurbished for use at another site at any stage of its service life. Additionally, costs for installation and repair costs should be varied to determine the impact of the these costs on the economic analysis results.

D. Prime Power Engine-Generator. Commandant (G-ECV) will procure and provide the high-endurance diesel engine-generator sets. The generator is a brushless generator rated at 0.8 power factor, with a voltage output of 120 VAC, 60 hertz, single phase. For steady operation, voltage regulation is within ±1% and frequency regulation is within ±3%. The engine is an air cooled, four-cycle diesel modified for extended operation by converting it to dry sump operation and adding a 35 gallon lube oil reservoir. There are two engine models currently in place: the SR and ST. Both are no longer manufactured but the ST will be supported until 1998. Currently, there are five types of engines in use, the last two are in the stock system:

MODEL	CYLINDERS	BHP	KW RATING
SR-2	2	12.0	6.5
SR-3	3	18.0	9.8
ST-1	1	7.3	3.9
ST-2	2	14.6	8.0
ST-3	3	21.9	11.5

1. In the prime power system, the primary engine-generator will run continuously until ready for overhaul, at which time the secondary engine-generator will be plugged into the primary receptacles on the LPC and a rotational spare engine-generator will be installed and plugged into the secondary receptacles. The secondary engine-generator should be exercised for a 1 hour period weekly. During this period, it carries the station load, but the primary engine-generator continues to run. This exercise is necessary to maintain the secondary engine-generator in a state of readiness, to periodically "prove" its ability to automatically assume the signal load at any time, and to document and record the test. Rotational spare engine-generators are provided by Commandant (G-ECV).

   a. Engine Lube Oil. The following types of oil are recommended for use in Lister SR and ST series diesel engines:

      Above 45 F: MIL-L-2104C Grade 30 Lube Oil

      32 F to 45 F: MIL-L-46152 Grade 20W40 Lube Oil

Below 32 F: MIL-L-46152 Grade 10W30 Lube Oil

2. Engine Changeout. When regularly serviced at maximum 90 day intervals, the high endurance diesel engines provided by Commandant (G-ECV) for prime power use should be capable of providing in excess of 20,000 hours of reliable service between major overhauls.

   a. The ultimate endurance of the engine can be determined through district records. Engineers at all maintenance levels should insure that all ordinary corrective maintenance measured have been followed before an engine is removed from an aid.

   b. Failure of corrective maintenance action to restore the engine's ability to carry the actual signal load at the aid with 58.2-61.8 Hz stable frequency regulation should normally be the only criterion for removal of the engine from the aid. The only exceptions are if the engine is making abnormal noises, fails to start reliably, has excessive oil consumption or leakage.

3. Engine Major Overhaul. Overhaul of fuel injection system components and engines should be accomplished at Coast Guard engine overhaul facilities. Districts with few engine-generators may want to explore the use of other district's facilities who have greater experience and resources in overhauling engines. Commercial services, if used, should be approved by the CEU staff. Overhauled units should be tested in accordance with COMDTINST M10500.39, Overhaul Guide Specification for Lister SR Diesel Engines.

4. Engine-Generator Size Selection. If prime power engine-generators are required, the preliminary step in sizing them is to determine the maximum average power required at the aid. Figure 3-2 lists the maximum input power requirements for the standard equipment. Some of the equipment operates continuously, some intermittently. Figure 3-2 does not include any nonstandard loads, such as electric space heaters or interior lighting. These loads must be added to the standard loads to arrive at the final engine-generator size selection.

   The present standard high endurance plant may be subjected to a maximum continuous overload of 110 percent for less than one hour and a continuous load of 100 percent. Prolonged operation below 75 percent of rated load can significantly reduce engine overhaul intervals due to the effects of carbonization.

EQUIPMENT NOMENCLATURE	MAX RANGE/ POWER	STATED TECHNICAL MANUAL REQUIREMENTS (IF ANY)	MAXIMUM LOAD VOLTAMPS	WATTS
Radio Aids				
NX250BD	62.5W	120VAC, 4.6A, 0.9PF	530	477
NX1000BD	250W	120VAC, 14.6A, 0.9PF	1680	1512
NX4000BD	1000W	240VAC, 26A, 0.9PF	6000	5400
Racon		12VDC, 0.21A		
Sound Signals				
CG-1000	2 miles	120VAC, 14A (Derated)	1680	(1344)
FA-232	1/2 mile	12VDC, 1.8A		
FA-232/02	1 mile	12VDC, 3.6A		
FA-232/04	2 miles	12VDC, 9.0A		
Main Lights				
DCB-24	24 miles	120VAC, 14A	1680	(1500)
DCB-224	26 miles	120VAC, 22A	2640	(2400)
Drum Lens	13 miles	120VAC, 2.1A	250	250
	15 miles	120VAC, 8.3A	1000	1000
FA-251-AC	17 miles	120VAC, 1.25A	(160)	(160)
VRB-25	22 miles	12VDC, 9.17A, 0.1A (motor)		(110)
Auxilary Equipment				
Enviromental Control Unit	1HP	120VAC	1500	(1300)
Daytank	1/3HP	120VAC	(828)	(662)
12V Batt Chrgr	25A	120VAC	(940)	850
24V Batt Chrgr	10A	120VAC	(720)	650
Fog Detector		12VDC, 2.0A		(30)
Lighthouse Pwr Controller		12VDC		(25)
Fire Control Unit		12VDC		(10)
Audio Visual Controller		12VDC		(80)
ACMS (Remote & Radio Link)		12VDC		(30)
LEACMS		12VDC		(9)

Notes:

1. PF = Power Factor
2. Values in parenthesis are an estimate.

FIGURE 3-2
EQUIPMENT INPUT POWER REQUIREMENTS

E. Auxiliary Equipment.

1. High Endurance Standby Engine-Generator. The standby engine-generators should be identical to prime power generators, as described previously. The LPC, described below, should be used when installing a standby engine-generator. The standby engine-generator should be exercised weekly.

   For a lighthouse with a standby engine-generator that will not run during exercise periods in the cold winter months, immersion type oil heaters may be installed. They are available from Kim Hotstart manufacturing of Spokane, Washington, part number OL-18201-68-EP.

2. Lighthouse Power Controller (LPC). The LPC is a general purpose programmable controller designed to provide monitoring and control for either a pair of diesel engine-generators or commercial power and a standby engine-generator set. Power switching is accomplished by an ancillary transfer switch using two AC contactors. The controller ensures that AC Power of 110 to 125 volts, 60Hz ± 3% is supplied to the load at all times and checks for proper oil pressure and temperature, thus preventing damage to the load or generator. If voltage or frequency extremes are exceeded, a quick or delayed disconnect will occur, depending on the range of extremes. The controller than initiates a start-up sequence and connects the standby engine-generator set to the load, providing it is operating properly. The controller provides status information to the ACMS and can receive a signal to exercise the standby engine-generator set.

3. Fuel Supply System. The fuel for primary and standby power systems should be number 2 diesel fuel.

   a. Precautions should be taken to insure that the fuel is as free as possible from suspended impurities and water. Diesel fuel meeting the quality standards of MIL-F-16884 should be used. It is suggested that a minimum fuel tank capacity of 275 gallons be used for standby generators. For prime power systems, fuel storage for 14 months of continuous operation is desirable, but not mandatory. Tank capacity can be determined by using the fuel consumption rate shown on the data sheet for the standard engine-generators in COMDTINST M16500.3A. Fuel should be subjected to visual quality surveillance tests as stated in COMDTINST MM9000.6, Naval Engineering Manual. At least two tanks are necessary for isolation and repair or cleaning without disruption of the fuel supply.

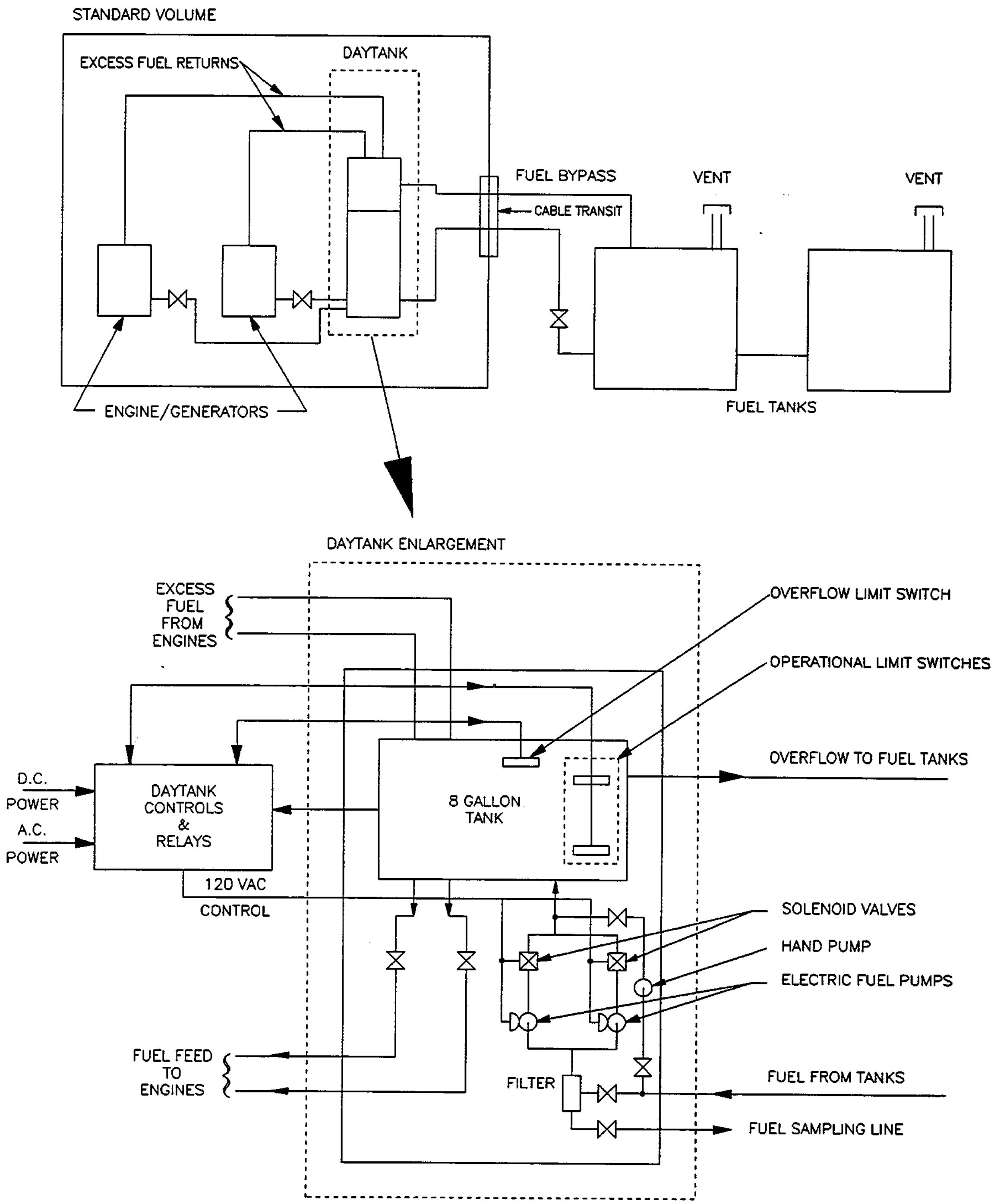


FIGURE 3-3
DAYTANK FUEL SUPPLY SYSTEM

b. An inside daytank is required at all high endurance engine-generator sites. The fuel should pass through a filter/water separator at the inlet to the daytank. The elevation of the daytank should provide a positive head of fuel to the engine(s) at all times. Figure 3-3 is a diagram of the standard eight gallon daytank system. It includes two 120VAC pumps that operate alternately to fill the tank. The lift capability of the pump is 15 feet. If the lift requirements exceed this limit, then the CEU should procure a system for that particular installation. A high level limit float switch is provided and should be checked upon installation of the system. A Parker Hannifin, Corporation, model 2020SM filter/water separator is recommended for all existing and new installations. To prevent fuel from leaking back into a nonoperating system, a separate fuel return line should be run from each engine back to the top of the fuel supply tank. A biocide, such as "Biobor JF", should be added to the stored fuel during each fuel replenishment to retard bacterial growth. A manually operated pump is furnished as part of the daytank to provide fuel to the engine-generator when starting a completely cold system at prime powered sites.

c. The Lister diesel engines used in the standard engine-generators have a lift pump installed. Remove the lift pump from the engine at sites where there is a gravity feed system in lieu of a daytank, and the gravity feed system has a head greater than six feet above the engine's crankshaft. Excessive head pressure from a gravity feed system will rupture the diaphragm in the fuel lift pump and contaminate the engine's lube oil.

4. <u>Environmental Control Unit</u>. The prime power standard volume, whether a converted existing lighthouse structure or a portable fiberglass container, will have an environmental control unit installed for air ventilation and filtration. The environmental control unit (Figure 3-4) for the prime powered engine-generator standard volume is comprised of an air intake assembly, air discharge assembly and gravity damper. Mixing louvers in the intake assembly mix intake air from the outside with warm air from inside the volume. The mixing louvers are thermostatically controlled.

a. The environmental control unit provides clean air for cooling the standard volume and makeup air for engine combustion and engine cooling. An electrically driven fan motor, mounted outside the intake mixing box, pulls air through the intake hood and forces it through an inertial filter. The filter cleans the

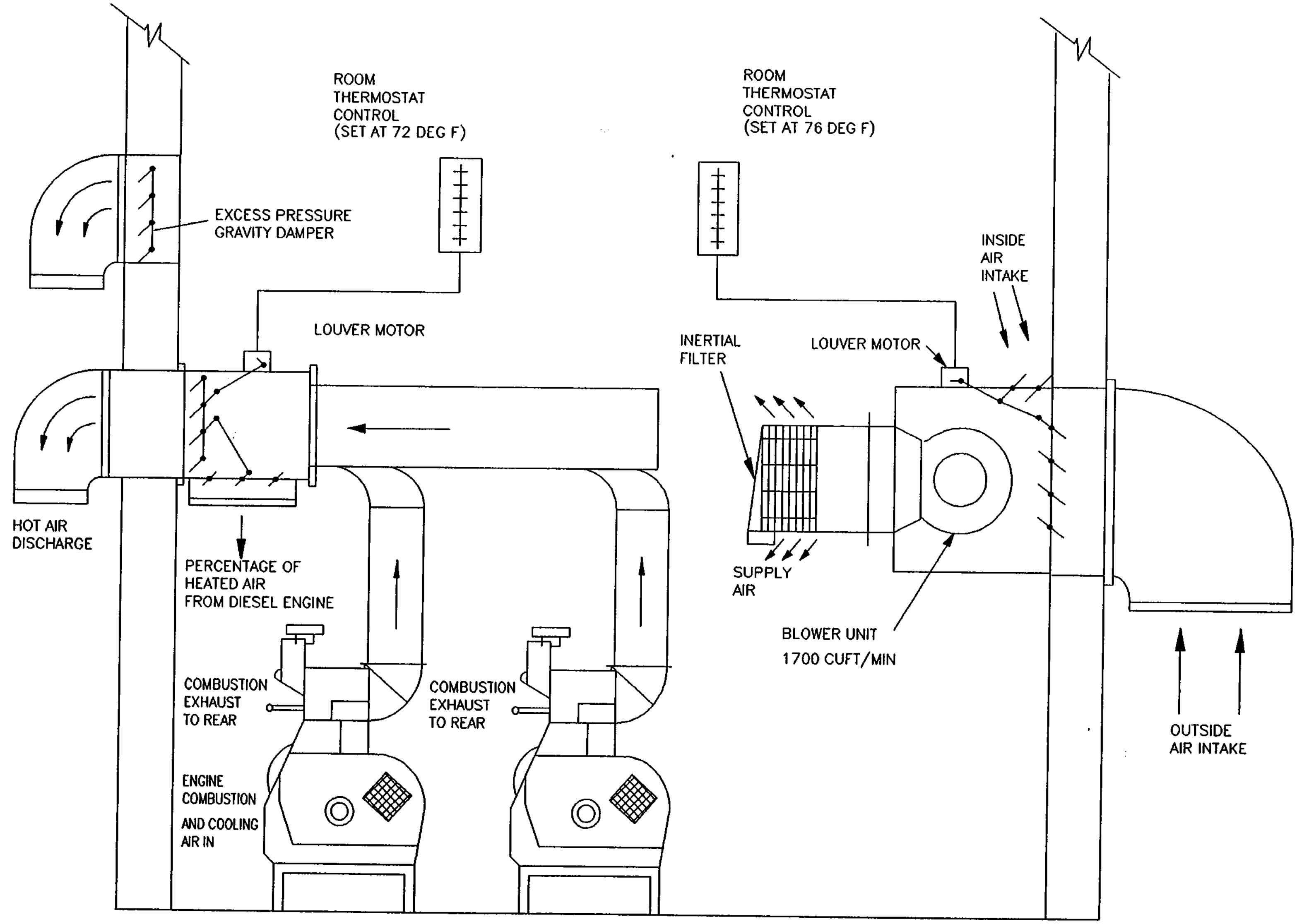


FIGURE 3-4
ENVIRONMENTAL CONTROL UNIT
(Prime Power Engine-Generator System)

air of particles before it enters the standard volume by forcing it through an approximate 170 degree turn at relatively high velocity. The foreign particles, being heavier than air, cannot make the turn and are ejected under the force of 10 percent of the total airflow which is discarded for this purpose. To insure proper filtering action and thermal control in the volume, the fresh air intake duct system must allow a minimum 1,400 cubic feet per minute (CFM) airflow into the volume. The residue from the intake air is expelled from the filter through a dust collection chute to the exterior of the standard volume. The outside air intake louvers are fully opened at room temperatures of 74 degrees and above and are closed at 72 degrees F and lower. The inside air intake louvers for room air are fully closed at 74 degrees F and above, and opened at 72 degrees F and lower.

b. The exit air vent assembly also contains thermostatically operated louvers which regulate the quantities of heated engine air discharged outside and inside the standard volume. At room temperatures of 74 degrees F and above, all heated air from the engine is discharged outside the volume. At room temperatures below 72 degrees F, heated air, as required, is discharged into the interior of the volume. The standard volume also contains through-the-wall gravity operated dampers for venting excess static pressure when the air louvers are fully open at room temperatures above 74 degrees F.

c. The standard volume for standby power systems (whether in an existing structure or a fiberglass container) is equipped with an environmental control unit which is less complex than that of the engine-generator prime power system. The purpose of the standby environmental control unit (Figure 3-5) is to provide cooling air for the standby volume and makeup air for engine combustion and cooling. The exhaust fan and louver assembly turn-on/open only when the engine generator is running. An optional commercially powered heater, for cold climates, is switched off when the engine-generator is operating. At aids where commercial power failure is likely to be long term (2-3 months), then the standard prime power environmental control unit should be installed.

5. Fire Suppression System. Halon 1301 fire suppression systems were previously supplied with prime power standard volumes. Current systems should be maintained until parts are no longer available or the agent is discharged. Replacements or systems for new installations are not planned. Details of currently

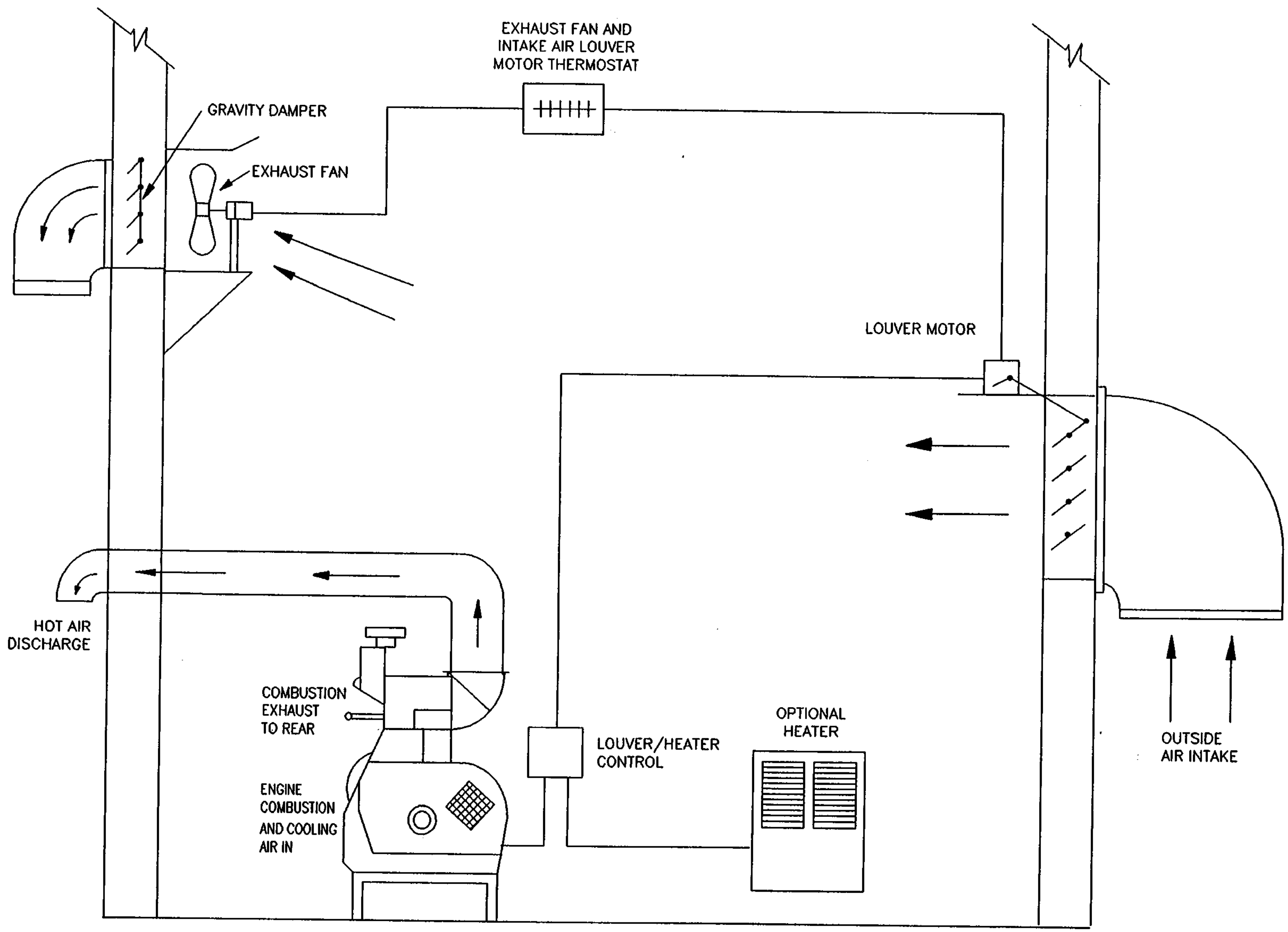


FIGURE 3-5
ENVIRONMENTAL CONTROL UNIT
(Standby Engine-Generator System)

installed systems are described in Standard Drawing 130915.

6. Battery Systems. All standard engine-generator equipped aids will have a source of 24 volt DC for starting the engine, operating the lighthouse power controller and powering the fire suppression system (if equipped). Category I, II and III aids will also have a separate source of 12 volt DC for operation of the signal control equipment and DC emergency signals. Under normal operating conditions, the direct current will be supplied by batteries charged by the main AC buss. In the event of a total outage of both primary and secondary (or standby) power sources, the 12 volt batteries will supply power to the emergency light and emergency sound signal until primary power is restored or the batteries are exhausted.

   a. High discharge rate nickel-cadmium (Nicad) storage batteries of the vented, pocket plate, construction should be used for the 24VDC battery system. The battery system is comprised of 20 cells wired in series. Each cell is rated for approximately 100 ampere-hours and has a nominal voltage of 1.2 volts. Salient features and ordering information is available in COMDTINST M16500.3.

   b. The 24VDC battery charger, required to charge the 24 volt engine starting batteries, will be provided by Commandant (G-ECV-3). The charger is designed to float charge Nicad or lead-acid batteries and is rated at a current of 10 amps. The charger is wall mounted and has three sets of connections; AC input, DC output, and temperature sensing of the battery. It also has adjustments for "float" and "equalize" voltage levels and an equalizing timer.

   c. Certain categories of automated aids will be equipped with a 12VDC power source which provides power to the radio link, ACMS during normal station operation, and power to the emergency light and emergency sound signal when AC power or the main signal fails.

   d. Nickel-cadmium (Nicad) storage batteries of the vented, pocket plate construction should be used for the 12VDC emergency battery system. The battery system is comprised of 10 cells wired in series. Each cell is rated for approximately 80, 240 or 400 ampere-hours (see paragraph f, below) and has a nominal voltage of 1.2 volts. A list of vendors and salient features are available from Commandant (G-ECV-3).

Emergency Light Typical Duty Cycle	Emergency Sound Signal								
	None		FA-232 Duty Cycle			FA-232/02 Duty Cycle			
			10%	13.3%	20%	10%	13.3%	20%	
None	6.0		48.0	61.0	87.0	90.0	116.0	168.0	240 AH
1.67	15.2	80 AH	57.2	70.2	96.2	99.2	125.2	177.2	
3.33	22.5		64.5	77.5	103.5	106.5	132.5	184.5	
5.00	29.8		71.8	84.8	110.8	113.8	139.8	191.8	
6.67	37.1		79.1	92.1	118.1	121.1	147.1	199.1	
8.33	44.4		86.4	99.4	125.4	128.4	154.4	206.4	
10.00	55.3		97.3	110.3	136.3	139.3	165.3	217.3	
13.30	66.3		108.3	121.3	147.3	150.3	176.3	228.3	
20.00	95.5		137.5	150.5	176.5	179.5	205.5	257.5	
33.30	152.4		194.4	207.4	233.4	236.4	262.4	314.4	
40.00	177.0		219.0	232.0	258.0	261.0	287.0	339.0	400 AH
100.00	409.2		451.2	464.2	490.2	493.2	519.2	571.2	

Notes:

1. The values in this table do not include a daylight control.
2. The 3.05a lamp requires 50% more power than the 2.03a lamp and produces virtually no increase in range. Therefore, the 3.05a lamp should not be used in emergency lights.
3. This table is calculated based on the load of the emergency signals and includes the ancillary power of the AC control and monitoring equipment. For solar powered aids, base the autonomy directly on the emergency signal load profile.

FIGURE 3-6
EMERGENCY AID POWER CONSUMPTION
(Ampere-hours consumed in 8 days)

e. The 12VDC battery charger, required to charge the 12 volt emergency batteries, will be provided by Commandant (G-ECV-3). The charger is designed to float charge Nicad or lead-acid batteries and is rated at a current of 25 amps. The charger is wall mounted and has three sets of connections; AC input, DC output, and temperature sensing of the battery. It also has adjustments for "float" and "equalize" voltage levels and an equalizing timer.

f. The emergency battery system for automated installations must be capable or providing a source of 12 volts DC to operate the emergency signals for about 8 days. Figure 3-6 is a guide for selecting the size of the battery bank to be used on each installation for most common equipment combination. Unique flash rhythms will require calculation of the average daily power consumption, as described in COMDTINST M16500.3.

g. The emergency batteries will operate the ACMS and radio link for 30 minutes following an AC power failure. After that time, these systems will be disconnected by a time delay relay in the AVC and full power will be devoted to the emergency light and emergency sound signal.

F. Solar Power Systems. When the requirements of Figure 3-1 are met, a solar power system may be installed at the aid. The components used in large solar power systems are in many cases the same or similar to minor aid hardware. The array usually consists of standard 35 watt solar panels, or high density 43 watt modules, a large liquid lead-acid battery and a charge controller. A drawing of a typical solar powered lighthouse is shown in Figure 3-17. Commandant (G-ECV-3) can provide assistance in designing large solar power systems using the Solarcalc computer program. Additional information on hardware used at solar powered lighthouses is detailed in COMDTINST M16500.3. With the exception of solar panels and batteries, all of the following equipment is available from Commandant (G-ECV-3) as free issue:

1. Main Solar Array. The solar array is sized to maintain a minimum of 80 percent state of charge on the battery during winter months and fully charged at all other times. The array is sized based on the actual output of solar panels. This is done because Siemens Solar Industries solar panels produce more power than rated which could cause overcharge conditions. This is not a concern on single panel minor aids, but could pose a problem on multi-panel arrays. Solar panels used for installations are standard 35 watt units available from SUPCEN. A limited number of high density 43 watt units are available for use on small platforms or where SHPOs

object to large array structures, however they do not fit the standard bolt pattern and do not have the robustness of the standard marine module. For this reason, these panels are not recommended for use offshore. The array support structure should be designed by the CEU. The structure should be large enough to accommodate additional solar panels in case Siemens versions are not available. The structure should be designed to survive a 100 year storm. Last, but most important, the structure must be designed so that servicing personnel can easily and safely access all of the solar panels from the front and back of the array.

2. Standby Solar Panel. The standby solar panel charges the standby battery and keeps it fully charged until it is needed to power the emergency signals. The solar panel can be mounted on the support structure of the main solar array or on a separate mounting stand. The solar panel is different from the main solar panels in that it produces a higher output voltage to effectively charge the Nicad battery. Solar panels that are authorized for use are the Siemens Solar Industries M75 or the Solarex Corporation SX-38MM. The blocking diode is not installed in this panel as this function is performed in the Solar Distribution Box (SDB).

3. Local Terminal Boxes. Local Terminal Boxes (LTBs) are enclosures containing terminal strips used to combine the inputs from up to ten solar panels. Because of wire size limitations on the output, it is suggested that only five to eight solar panels be terminated in these boxes. The LTB is located close to the group of panels feeding it thereby keeping the wire run from the solar panel as short as possible.

4. PV Combiner Box. The PV Combiner Box combines the input from all of the LTBs, and provides fuse and lightning protection. The output is divided up (usually evenly) into three strings to feed into the charge controller. It is typically located on or near the array to keep wire runs from the LTBs as short as possible.

5. Charge Controller. The charge controller prevents the battery from overcharging during summer months. It is used when the maximum charge rate of the array, in amperes at 13.3 volts, exceeds the self regulation rate of C/60 (where C is the capacity in ampere-hours) for liquid lead-acid batteries. The three inputs from the PV Combiner Box are fed through circuit breakers into the charge controller; one input is connected to the battery to serve as a "float charger", the other two are controlled by mercury contact relays that open when a predetermined battery voltage is reached. When the average monthly temperature drops below 50 degrees F and

the difference of the average monthly temperatures exceeds 20 degrees F, a temperature controller can be installed in the charge controller to interrupt the signal to the mercury relays allowing full charging during cold periods.

6. Main Battery. The battery used for stationary installations above 350 ampere-hours is the Exide Corporation EI and FHGS series cells. These cells are tubular design, have clear cases to facilitate visual checks, and contain liquid electrolyte (which is more forgiving that other technologies). Cells are two volts, requiring six cells connected in series to produce 12 volts. The battery size is determined by calculating the maximum daily load (which occurs on December 21 in the northern hemisphere) multiplied by the desired autonomy (8-12 days typically) divided by 80% (a derating factor for lost capacity during its useful life), divided by the minimum anticipated state of charge (80% minimum).

7. Standby Battery. The standby battery is the same as described in paragraph E.6.d. When used with the SDB, it drives the emergency signals when the main battery is disconnected. When used with the Multiarray Controller (MAC), the standby battery will operate the main signals when the main battery is disconnected. The size of the standby battery should be based on a slighter longer autonomy of 12 days.

8. Battery Charging. A 12 volt DC engine-generator is available from Commandant (G-ECV-3) to provide the initial freshening charge on the battery and to charge it up if a failure occurs. The generator is diesel powered, portable (120 pounds), capable of providing 70 amperes continuous, 100 amperes maximum, adjustable output voltage, and carries enough fuel for 24 hours of operation.

9. Special Considerations. Voltage drop at 12 volt aids is a major consideration, especially with the loads typically found at solar powered lighthouses and ranges. Undersized conductors can cause inadequate battery charging, low voltage at the optic causing a reduction in intensity and range, and overheating of wires. However, use of "oversized" conductors in these situations provides a simple and effective solution to the problem of voltage drop. Guidelines for proper conductor sizing are available in Standard Drawing 140410 and from Commandant (G-ECV-3).

Average Maintenance Costs for Alternative Power Systems — Aid Name & LLNR:

(Prepared:)

	Solar Power System		Subcable w/ E/G Standby		Subcable Only		Prime Power	
	Trips	Cost	Trips	Cost	Trips	Cost	Trips	Cost
1. Regular Service								
2. Discrepancy Visits								
3. Engine Change-Out								
4. Solar Battery Change-Out								
5. Crew Preparation Shoreside								
6. Engine Overhaul								
7. Refueling								
8. Fuel and Lubricants								
9. Utility Costs								
10. Cable Failure Repair								
11. Other Miscellaneous Costs								
TOTAL SYSTEM COSTS								

ASSUMPTIONS:

FIGURE 3-7
COST ESTIMATING FORM FOR
POWER SYSTEM ANNUAL MAINTENANCE

5-00219/ P.O.35786

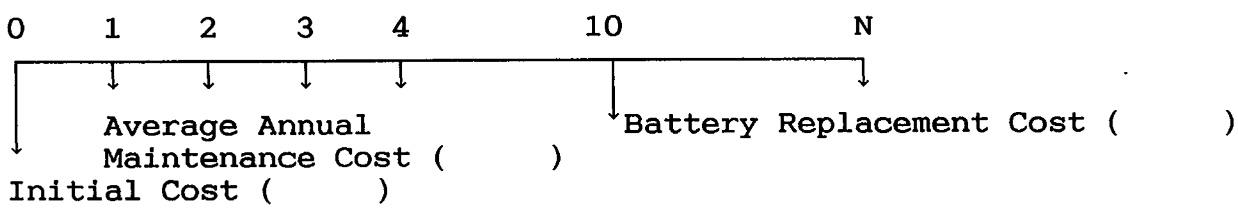
Aid Name: ________________

Economic Life (N): ________

NPV: ____________________

UAC: ____________________

Cost Flow Diagram:



Net Present Value (NPV) = Initial Cost + Present Value (PV) of Average Annual Maintenance Cost (AMC) + Present Value of Battery Replacement Cost (BRC)

NPV = Initial Cost + PV(AMC) + PV(BRC)

Equivalent Uniform
Annual Cost (UAC) = NPV / Cumulative Sum Factor (CSF) for Year N

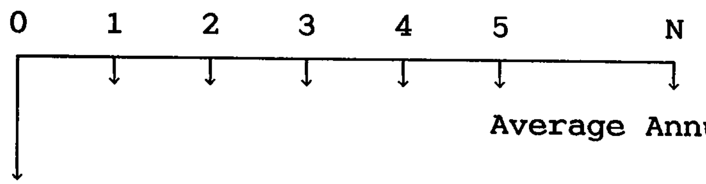
Notes:

1. The initial cost is based on the materials labor costs to procure and install the solar power system. Actual costs will vary based on: size of the power system, availability of in-house industrial facilities, personnel and transportation costs, and how much site preparation is required.
2. Average annual maintenance costs (AMC) from figure 3-1
3. Cumulative Sum Factor (CSF) from table B of table 3-11; pick factor for nth year.
4. Present Value (PV) of AMC = (AMC) x (CSF)

FIGURE 3-8
SOLAR POWER SYSTEM COST ESTIMATE

Aid Name: ____________
Economic Life (N): ________
NPV: ____________
UAC: ____________

Cost Flow Diagram:



Average Annual Maintenance Cost (   )

Initial Cost (   )

Net Present Value (NPV) = Initial Cost + Present Value (PV) of Average Annual Maintenance Cost (AMC)

NPV = Initial Cost + PV(AMC)

Equivalent Uniform
Annual Cost (UAC) = NPV / Cumulative Sum Factor (CSF) for Year N

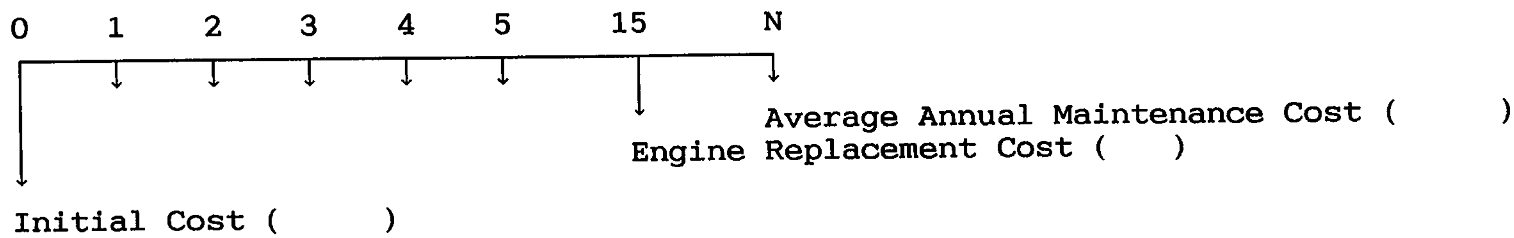
Notes:

1. The initial cost is based on the materials labor costs to procure and install the power cable. Actual costs will vary based on: route survey, length of cable run to include cable cost and installation, and standby E/G (if used).
2. Average annual maintenance costs (AMC) from figure 3-1
3. Cumulative Sum Factor (CSF) from table B of table 3-11; pick factor for nth year.
4. Present Value (PV) of AMC = (AMC) x (CSF)

FIGURE 3-9
SUBMARINE CABLE POWER SYSTEM COST ESTIMATE

Aid Name: ____________
Economic Life (N): ________
NPV: ____________
UAC: ____________

Cost Flow Diagram:



Net Present Value (NPV) = Initial Cost + Present Value (PV) of Average Annual Maintenance Cost (AMC) + Present Value (PV) of Engine Replacement

NPV = Initial Cost + PV(AMC) + PV(ER)

Equivalent Uniform Annual Cost (UAC) = NPV / Cumulative Sum Factor (CSF) for Year N

Notes:

1. Initial cost: Includes standard volume in which many of the components must be custome fabricated. Include transportation and site preparation.
2. Average annual maintenance costs (AMC) from figure 3-1
3. Engine Replacement Cost is estimated to be $20K for both engines, not including transportation.
4. Cumulative Sum Factor (CSF) from table B of table 3-11; pick factor for nth year.
5. Present Value (PV) of AMC = (AMC) x (CSF)

FIGURE 3-10
PRIME POWER SYSTEM COST ESTIMATE

Average Maintenance Costs for Alternative Power Systems (Prepared: Nov 94)							Aid Name & LLNR: Long Branch Light LLNR 125	
	Solar Power System		Subcable w/ E/G Standby		Subcable Only		Prime Power	
	Trips	Cost	Trips	Cost	Trips	Cost	Trips	Cost
1. Regular Service	2	7300	2	7300	2	7300		
2. Discrepancy Visits	1	3650	2	7300	1	3650		
3. Engine Change-Out			0.1	1000				
4. Solar Battery Change-Out	0.1	1000						
5. Crew Preparation Shoreside		1900		2500		1800		
6. Engine Overhaul			0.1	100				
7. Refueling			.25	1300				
8. Fuel and Lubricants				400				
9. Utility Costs				1800		1800		
10. Cable Failure Repair			0.2	760	0.2	760		
11. Other Miscellaneous Costs								
TOTAL SYSTEM COSTS		13,850		22,460		15,310		

FIGURE 3-11
COST ESTIMATING FORM FOR
POWER SYSTEM ANNUAL MAINTENANCE

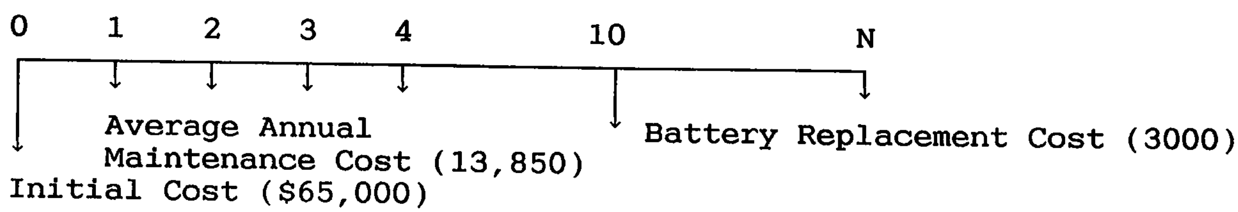
ASSUMPTIONS:

1. One ANB @ $418/hr with an additional crew of 2 @ $19/hr for one 8 hour day.
2. Same as above.
3. Engine change-out every 10 years based on a WLB @ $1034/hr for 6 hours plus costs for 1, above
4. Solar battery change-out every 10 years; same as 3, above.
5. Crew Preparation shoreside is equivalent to total time spent at aid by personnel (3.1 days x 8 hrs/day $19/hr x a crew of 4.
6. Engine overhaul @ $1000 for a Lister ST-2
7. Refueling once every 4 years based on a WLB @ $1034/hr for 5 hours.
8. Fuel and Lubricant based on 200 gallons diesel @ $1.20/gal plus 35 gallons of lube oil @ $1.00/qt.
9. Utility costs based on DCB-36 beacon (1500W) + AVC (80W) + 12/24 volt battery chargers (150W avg) + ELG-300/02 (134W avg) on 24 hrs/day @ $0.11/KWH
10. Cable Failure Repair based replacement cost of $3.8K every 5 years.

FIGURE 3-11
COST ESTIMATING FORM FOR
POWER SYSTEM ANNUAL MAINTENANCE
(cont'd)

Aid Name: Long Branch Light
Economic Life (N): 20 yrs
NPV: $213,250
UAC: $20,130

Cost Flow Diagram:



Net Present Value (NPV) = Initial Cost + Present Value (PV) of Average Annual Maintenance Cost (AMC) + Present Value of Battery Replacement Cost (BRC)

NPV = $65,000 + $13,850(10.5938) + $3000(0.5083)

NPV = $213,250

Equivalent Uniform Annual Cost (UAC) = NPV / Cumulative Sum Factor (CSF) for Year N

UAC = $213,250 / 10.5938

UAC = $20,130

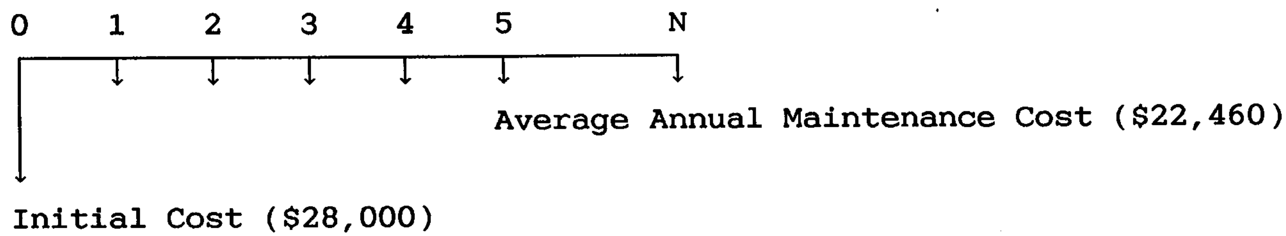
Notes:

1. The initial cost is based on the materials labor costs to procure and install the solar power system. Actual costs will vary based on: size of the power system, availability of in-house industrial facilities, personnel and transportation costs, and how much site preparation is required.
2. Average annual maintenance costs (AMC) from figure 3-5
3. Cumulative Sum Factor (CSF) from table B of table 3-11; pick factor for nth year.
4. Present Value (PV) of AMC = (AMC) x (CSF)

FIGURE 3-12
CONVERT TO SOLAR POWER SYSTEM COST ESTIMATE

Aid Name: Long Branch Light
Economic Life (N): 20 yrs
NPV: $265,930
UAC: $25,100

Cost Flow Diagram:



Net Present Value (NPV) = Initial Cost + Present Value (PV) of Average Annual Maintenance Cost (AMC)

NPV = Initial Cost + PV(AMC)

NPV = $28,000 + $22,460(10.5938)

NPV = $265,930

Equivalent Uniform Annual Cost (UAC) = NPV / Cumulative Sum Factor (CSF) for Year N

UAC = $265,930 / 10.5938

UAC = $25,100

Notes:

1. The initial cost is based on the materials labor costs to procure and install the power cable. Actual costs will vary based on: route survey, length of cable run to include cable cost and installation, and standby E/G (if used).
2. Average annual maintenance costs (AMC) from figure 3-5
3. Cumulative Sum Factor (CSF) from table B of table 3-11; pick factor for nth year.
4. Present Value (PV) of AMC = (AMC) x (CSF).

FIGURE 3-13
REPLACE EXISTING MARINE CABLE POWER SYSTEM COST ESTIMATE

Average Maintenance Costs for Alternative Power Systems (Prepared: Nov 94)								Aid Name & LLNR: Isles of Shells LLNR 1234
	Solar Power System		Subcable w/ E/G Standby		Subcable Only		Prime Power	
	Trips	Cost	Trips	Cost	Trips	Cost	Trips	Cost
1. Regular Service	2	7300					4	14,600
2. Discrepancy Visits	1	3650					3	10,950
3. Engine Change-Out							.5	5000
4. Solar Battery Change-Out	0.1	1000						
5. Crew Preparation Shoreside		1900						4560
6. Engine Overhaul								500
7. Refueling							1	5000
8. Fuel and Lubricants								8400
9. Utility Costs								
10. Cable Failure Repair								
11. Other Miscellaneous Costs								
TOTAL SYSTEM COSTS		13,850						49,000

FIGURE 3-14
COST ESTIMATING FORM FOR
POWER SYSTEM ANNUAL MAINTENANCE

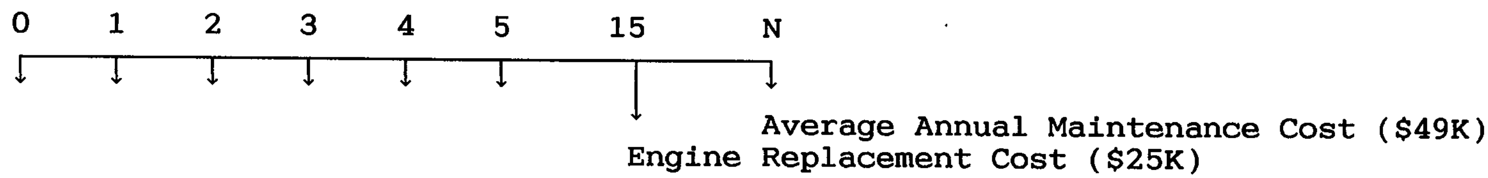
ASSUMPTIONS:

1. One ANB @ $418/hr with an additional crew of 2 @ $19/hr for one 8 hour day.
2. Same as above.
3. Engine change-out every 2 years based on a WLB @ $1034/hr for 6 hours plus costs for 1, above
4. Solar battery change-out every 10 years; same as 3, above.
5. Crew Preparation shoreside is equivalent to total time spent at aid by personnel (3.1 days x 8 hrs/day $19/hr x a crew of 4.
6. Engine overhaul @ $1000 for a Lister ST-2
7. Refueling once every year based on a WLB @ $1034/hr for 5 hours.
8. Fuel and Lubricant based on 6570 gallons diesel @ 1.20/gal plus 140 gallons of lube oil @ $1.00/qt.

FIGURE 3-14
COST ESTIMATING FORM FOR
POWER SYSTEM ANNUAL MAINTENANCE
(cont'd)

Aid Name: Isles of Shells
Economic Life (N): 20 yrs
NPV: $528,150
UAC: $49,850

Cost Flow Diagram:



Net Present Value (NPV) = Present Value (PV) of Average Annual Maintenance Cost (AMC) + Present Value of Engine Replacement Cost

NPV = PV(AMC) + PV(ER)

NPV = $49,000(10.5938) + $25,000(.3624)

NPV = $528,150

Equivalent Uniform Annual Cost (UAC) = NPV / Cumulative Sum Factor (CSF) for Year N

UAC = $528,150 / 10.5938

UAC = $49,850

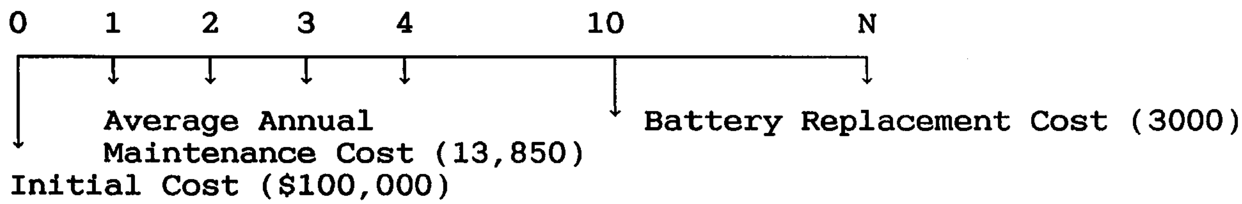
Notes:

1. Cost is based solely on annual maintenance requirements of power system.
2. Average annual maintenance costs (AMC) from figure 3-8
3. Engine Replacement Cost is estimated to be $20K for both engines, estimated $5K in transportation costs.
4. Cumulative Discount Factor (CSF) from table B of table 3-11; pick factor for nth year.
5. Present Value (PV) of AMC = (AMC) x (CDF).

FIGURE 3-15
MAINTAIN EXISTING PRIME POWER SYSTEM COST ESTIMATE

Aid Name: Isles of Shells
Economic Life (N): 20 yrs
NPV: $248,250
UAC: $23,430

Cost Flow Diagram:



Net Present Value (NPV) = Initial Cost + Present Value (PV) of Average Annual Maintenance Cost (AMC) + Present Value of Battery Replacement Cost (BRC)

NPV = $100,000 + $13,850(10.5938) + $3000(0.5083)

NPV = $248,250

Equivalent Uniform Annual Cost (UAC) = NPV / Cumulative Sum Factor (CSF) for Year N

UAC = $248,250 / 10.5938

UAC = $23,430

Notes:

1. The initial cost is based on the materials labor costs to procure and install the solar power system. Actual costs will vary based on: size of the power system, availability of in-house industrial facilities, personnel and transportation costs, and how much site preparation is required.
2. Average annual maintenance costs (AMC) from figure 3-8
3. Cumulative Sum Factor (CSF) from table B of table 3-11; pick factor for nth year.
4. Present Value (PV) of AMC = (AMC) x (CSF)

FIGURE 3-16
CONVERT TO SOLAR POWER SYSTEM COST ESTIMATE

Table A	Table B
PRESENT VALUE OF $1 (Single Amount-to be used when cash flows accrue in varying amounts each year)	PRESENT VALUE OF $1 (Cumulative Uniform Series-to be used when cash flows accrue in the same amount each year)

Project Year	7%	7%
1	0.9346	0.9346
2	0.8734	1.8080
3	0.8163	2.6243
4	0.7629	3.3872
5	0.7130	4.1002
6	0.6663	4.7665
7	0.6227	5.3892
8	0.5820	5.9712
9	0.5439	6.5151
10	0.5083	7.0234
11	0.4751	7.4985
12	0.4440	7.9425
13	0.4150	8.3575
14	0.3878	8.7453
15	0.3624	9.1077
16	0.3387	9.4464
17	0.3166	9.7630
18	0.2959	10.0589
19	0.2765	10.3354
20	0.2584	10.5938
21	0.2415	10.8353
22	0.2257	11.0610
23	0.2109	11.2719
24	0.1971	11.4690
25	0.1842	11.6532
26	0.1722	11.8254
27	0.1609	11.9863
28	0.1504	12.1367
29	0.1406	12.2773
30	0.1314	12.4087

* Table A factors are based on End-of Year compounding at a 7% annual discount factor. Table B factors represent the cumulative sum of table A factors through any given project year.

TABLE 3-1
PROJECT YEAR DISCOUNT FACTORS*

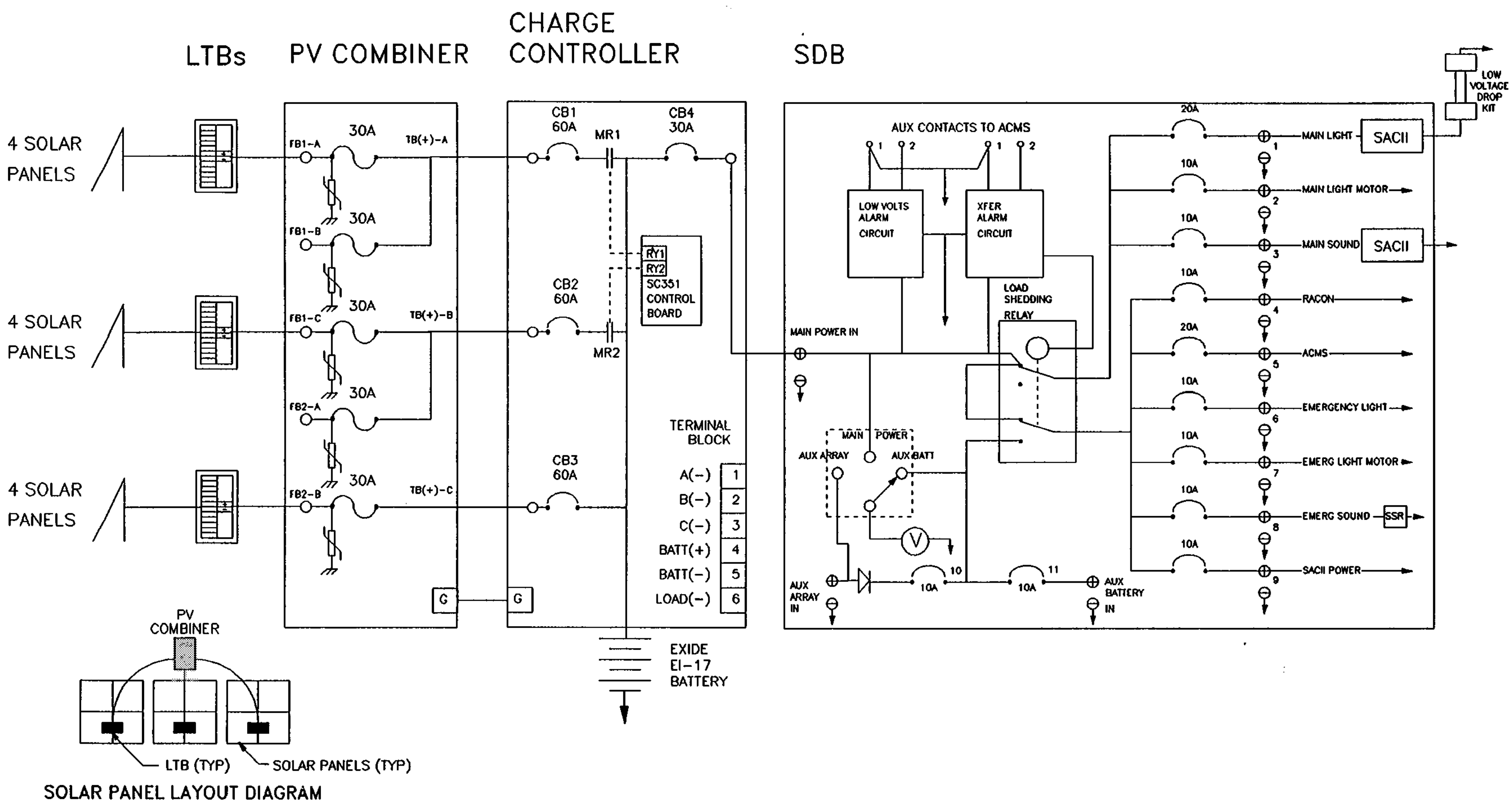


FIGURE 3-17
TYPICAL LARGE SOLAR POWER SYSTEM

CHAPTER 4. MONITOR AND CONTROL SYSTEMS

A. General. The capabilities of the Aid Control and Monitor System (ACMS), Low Energy ACMS (LEACMS) Remote Unit, and associated radio and telephone data links (both hard wire and cellular) are discussed in this chapter. The ACMS master unit consists of a Coast Guard Standard Workstation (CGSW) running the BTOS operating system. The ACMS was designed to monitor maximum complexity hardware configurations; hence, it is costly and complex, and reserved exclusively for that use. Descriptions of the status monitor and control functions are included. LEACMS Remote Unit was developed essentially for use in Solar Category I lighthouses and for other applications where very low power-consuming equipment is required.

B. Equipment Description. The monitor and control equipment prescribed for use with Category I & II aids consist of the ACMS and a dedicated two-way data link consisting of radio/modem, cellular, or hard wire telephone lines or a combination of the above. The ACMS remotely monitors and controls lights, sound signals, intrusion alarms, engine generators, fire systems, flooding systems, RACONs, etc. on Large Navigational Buoys (LNBs), lighthouses, and ranges. In 1990 the old ACMS Master Unit (MU) was replaced by the Coast Guard Standard Workstation (CGSW). As a result of the new ACMS MU, significant improvements were made in reliability, maintenance intensity, data storage, and troubleshooting diagnostics. Commandant (G-TES) procures the ACMS, LEACMS, and radio/modem/cellular/phone link equipment based on requirements stated in ATON modernization updates submitted by the district.

1. ACMS Master Unit (MU). Refer to the ACMS Master Unit technical manual (CG7610-01-GF4-1115) for a complete description of CGSW ACMS MU.

   a. CGSW Hardware. Hardware is ordered on the standard workstation contract and consists of the basic stand-alone workstation, cartridge tape streamer, 1MB RAM expansion module, and a standard low-speed asynchronous modem for dial-up communications with ACMS Transfer and Remote Units. The system consists of the following hardware and is installed in accordance with Unisys manuals:

      (1) 80286 Intel processor (B28-CPU) with 1MB RAM;
      (2) 14-inch video display;
      (3) Keyboard;
      (4) 20MB Winchester and 630KB floppy drives;
      (5) Three 1MB RAM expansion modules;
      (6) High-power power supply;
      (7) Line cord; and
      (8) Cartridge tape streamer.

b. Ancillary/Interfacing equipment required. The ACMS Master Unit must be connected to the Public Switched Telephone Network.

c. Equipment/Systems to which interfaced. ACMS Remote and Transfer Units are connected to the CGSW Master Unit either via a dial-up telephone line or a radio/modem (see Figure 4-1).

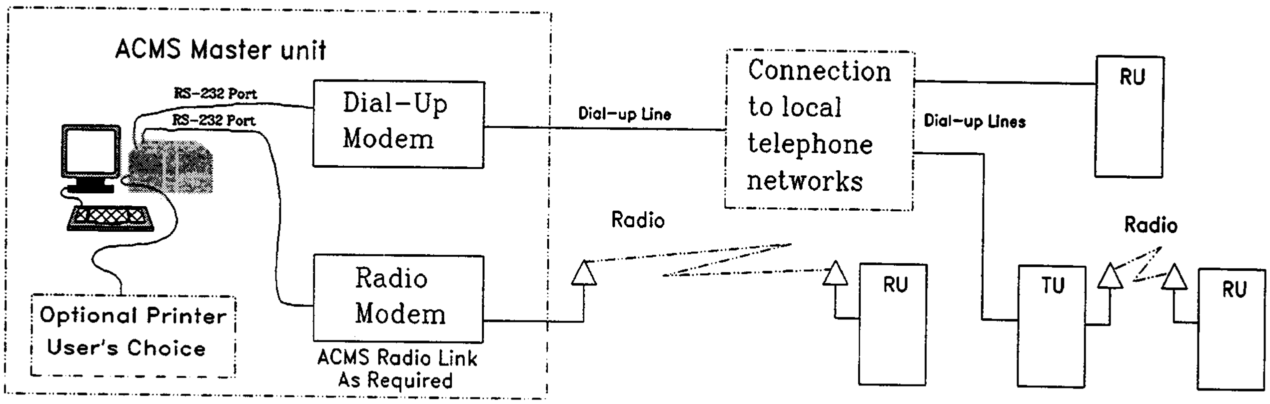


Figure 4-1

Aid Control-Monitor System

d. Functional/Performance Characteristics.

(1) Although leased telephone lines were used in the past, the CGSW Master Units will only support dial-up subscriber telephone lines and radio/modems. As with the original, a Transfer Unit will link a CGSW Master Unit and Remote Unit when a radio cannot be installed at the CGSW Master Unit's location.

(2) Watchstanders monitor the major aids to navigation in their area from the Master Unit which provides information about the aids being monitored based on routine data and exception status reports. The current configuration calls for monitoring the primary, secondary, and emergency lights and sound signals; primary and secondary radiobeacon status; the power system; the fog detector; and the intrusion and fire systems at a major fixed aid. Flooding conditions and the position of an LNB are also monitored. If a Remote Unit reports a status

change to one of the monitored items, the CGSW Master Unit will generate an alarm and display "ALARM" on its video display terminal.

(3) The watchstander acknowledges an alarm by pressing any key on the CGSW Master Unit keyboard. This action turns off the audible alarm signal and causes the system to list on the video terminal any further action required of the watchstander.

(4) The CGSW Master Unit also provides the watchstander with the following control functions at an aid:

(a) Reset the monitor equipment;
(b) Manually turn the sound signal on or off;
(c) Manually turn the radiobeacons on or off;
(d) Remotely reset the radiobeacon timing; and
(e) Remotely exercise the standby generator.

(5) Once a day, the CGSW Master Unit interrogates each of the Remote Units to which it is linked to check the communication links. The Remote Units respond by reporting the status of all of their input lines. Where long distance subscriber service phone lines are used in the communication links, the interrogations are scheduled to take advantage of discount long distance dialing rates.

(6) Remote Units are located at automated aids where they continually monitor the aid's equipment. A change of state on any input line causes the Remote Unit to initiate a call to the CGSW Master Unit. When the link is established, it then reports the state of all its input lines.

(7) The Transfer Unit is an intermediate system in the Master Unit/Remote Unit communication system which links with the CGSW Master Unit by a subscriber service phone line and with the Remote Unit by UHF radio. It permits the ACMS to be installed with the CGSW Master Unit many miles from a Remote Unit even though part of the communication link requires the use of line-of-sight radio.

(8) The system design also allows proper operation with radio repeater systems.

(9) The CGSW allows any number of Master Units as long as there is a means to establish a communications link to the Remote Unit (see

Figure 4-2). The Master Unit configuration contains one field where the operator designates the unit as a Primary, Secondary, or Non-Controlling Master Unit. Below is a brief explanation of the differences between the three types of Master Units:

Primary Master Unit: The Unit that has the primary monitoring responsibility for the ACMS Remote/Transfer Units. Status information can be forwarded to a Secondary Master Unit, but the information is first sent to the Primary Master Unit. When status forwarding is in affect the Primary Master Unit forwards the status information to the Secondary Master Unit. The Primary Master Unit has full control capabilities.

Secondary Master Unit: The Secondary Master Unit is the unit that receives the status information after working hours. This unit is normally located in a 24 hour manned space. It does not receive alarms directly from the Remote Units. The information is forwarded from the Primary Master Unit. However the unit has the same functions as the Primary Master Unit. It can interrogate Transfer Units/Remote Units directly or use any of its control commands. If the Primary Master Unit fails, the Secondary Master Unit can switch the Remote Units/Transfer Units to the Secondary phone numbers. The Remote and Transfer Units then call the Secondary Master Unit instead of the Primary Master Unit when there is a status change.

Non-controlling Master Unit: This Master Unit is a part-time ACMS Master Unit. It is used on an "as-needed" basis by service personnel to check on status information, for control of lighthouse systems, or for use during servicing. It is limited in several areas, but otherwise has full control capabilities. The Non-controlling Master Unit does not update Transfer Unit/Remote Unit real time clocks, it cannot perform the daily automatic interrogation, and it does not update Remote Unit ID numbers for the Transfer Units. These are all functions that are reserved for the controlling Master Unit.

e. Planned Life Cycle. The life cycle for the CGSW Master Unit is dependent on the CGSW contract. The anticipated life cycle for the radio/modem is seven to ten years.

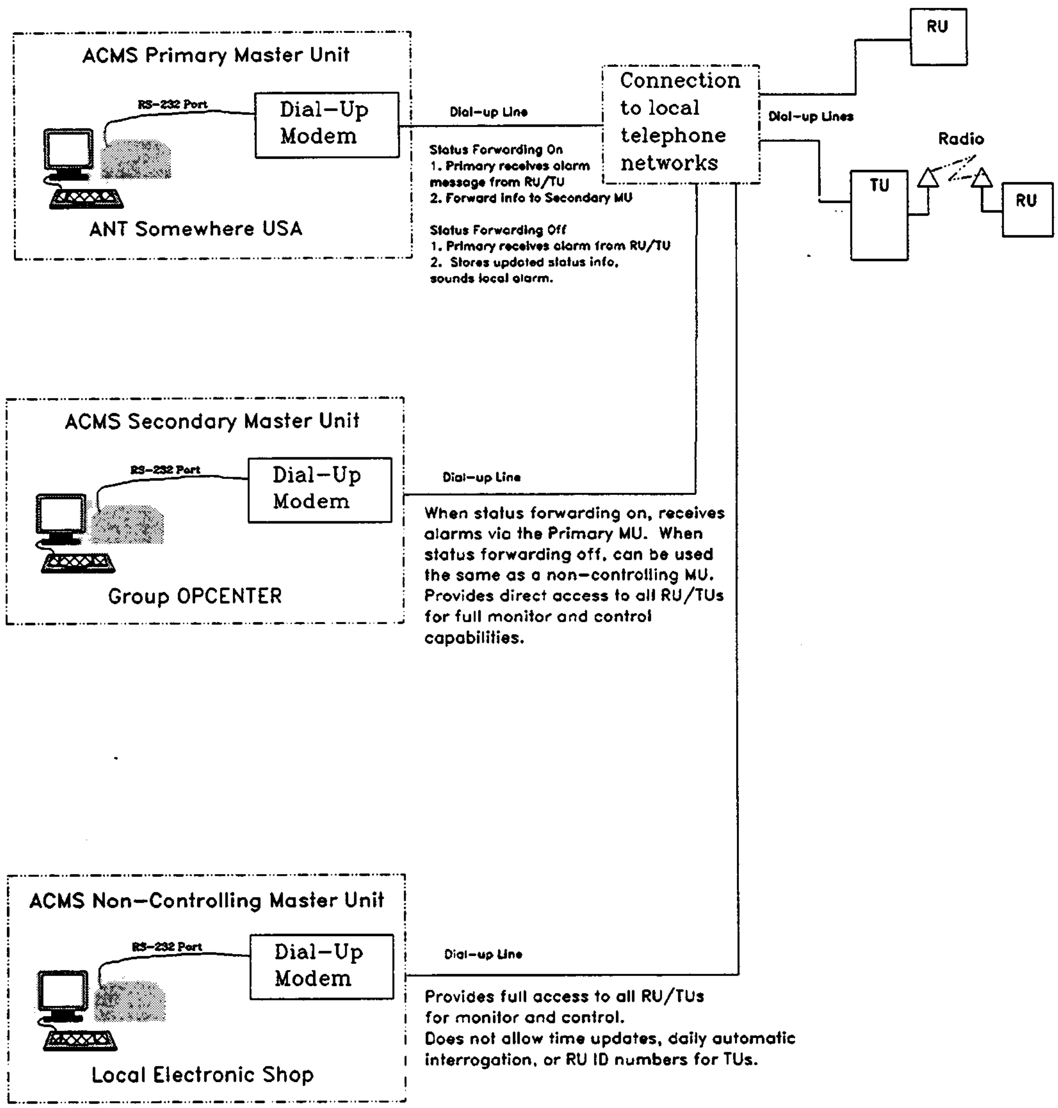


Figure 4-2

Primary, Secondary, and Non-controlling CGSW Master Units

2. <u>ACMS Remote Unit (RU)</u>. The OA-9211(V)3 AC and OA-9211(V)1 DC Units are self-contained Aid to Navigation Monitor Groups that will monitor activity and control equipment associated with lighthouses and large navigational buoys. The RU contains a STD Bus based micro-controller, optically isolated input monitors and output controls, and DC/DC converters to provide regulated, filtered operating voltages. The unit's embedded microprocessor constantly monitors the status of

the aid through optically isolated inputs. If a change in status is detected, the microprocessor generates a formatted message and transmits it to the associated Master Unit using the self-contained E. F. Johnson radio/modem or by dial-up modem.

3. ACMS Transfer Unit (TU). The ON-267(V)1 is a self-contained unit that will monitor activity and control equipment associated with TU. The TU contains a STD Bus based micro-controller, optically isolated input monitors and output controls, and an AC/DC converter to provide regulated, filtered operating voltages. The unit's embedded microprocessor constantly monitors the status of the site through optically isolated inputs. If a change in status is detected, the microprocessor generates a formatted message and transmits it to the associated Master Unit using the dial-up modem. The TU for the most part just passes information to and from the Master Unit to the Remote Monitor sites via E. F. Johnson radio/modem and dial-up modem.

4. LEACMS Remote Unit (RU). The GCF-W-1221 is a self-contained Aid to Navigation Monitor Group that will monitor activity and control equipment associated with a Solar Category I lighthouse. The single equipment cabinet contains a radio/modem unit, a STD Bus based micro-controller, optically isolated input monitors and output controls, and a DC/DC converter to provide regulated, filtered operating voltages. The unit's embedded microprocessor constantly monitors the status of the solar powered aid through optically isolated inputs. If a change in status is detected, the microprocessor generates a formatted message and transmits it to the associated Master Unit using the self-contained E. F. Johnson radio/modem.

5. Radio Link Equipment. Refer to the ACMS Master Unit Radio Communications Module technical manual for details on radio link connections and hardware.

   a. Radio links are implemented via a UHF radio transceiver and a modem connected to the CGSW serial port.

   b. The radio/modem consists of E. F. Johnson DL-3410 UHF telemetry module, RS-232 modem module, and 3400 interface module.

   c. At the present time, four frequencies have been reserved for monitor data links: 407.625, 407.975, 415.625, and 415.825 MHz. These are in the 406-420 Government UHF-FM band and will be allocated on an individual basis. The use of VHF is discouraged, but will be considered on an individual basis.

C. Interface with Other Aid Equipment. The Navaid Sensor Module, described in Chapter 2, provides the status and control interface between the light and sound signal systems and the monitor/control equipment. See current version of Standard Drawing 130413-6000, *ACMS Monitor Group Interconnection (Lighthouse)* for interconnection details. When using LEACMS at a solar powered lighthouse, the Solar Aid Controller II, also described in Chapter 2, provides the status and control interface between the light and sound signal systems and the monitor/control equipment. See current version of Standard Drawing 140410, *Category I Solar Powered Lighthouse System (Northern Latitude)* for interconnection details. The radiobeacon, discussed in Chapter 5, provides the interface between the Radiobeacon System and the monitor/control equipment. Engine-generator status and control is interfaced with the ACMS by the Lighthouse Power Controller (LPC), discussed in Chapter 3. Fire and intrusion alarms are connected directly to the monitor/control equipment.

D. Display and Control. Refer to the ACMS Master Unit technical manual (CG7610-01-GF4-1115) for complete detailed information.

1. STATUS (F1 Key). Pressing the status key displays the status of the highlighted ACMS unit in the Directory Display (Figure 4-3). The information displayed depends on the configuration setup entered using the Configuration Directory. If there is no status information available a message is displayed instructing the operator to interrogate the Remote/Transfer Unit (Figure 4-4). If the system displayed for a specific unit (e.g. Light, Sound, Security, Power, etc.) is working properly the "NORMAL" message is displayed. If the system is not working correctly a brief message is displayed along with the date and time the alarm was received. Recent alarms are indicated by a blinking alarm message for the first 24 hours. After 24 hours they are displayed in normal text without the blinking. A Master Unit and Transfer Unit status display includes only two entries, Communication System and Clock System. For a Master Unit these have no meaning and will always display a normal status.

a. Light Signal System. This displays the status of the main light, secondary light, and emergency light at a Remote Unit if the configuration indicates they are installed. The emergency light on an LNB is referred to as the Obstruction Light.

b. Sound Signal System. Indicates the normal/fail status of the primary and emergency sound signals and whether the signal is on or off. If there is a dual sound system, the display indicates reduced intensity

```
Status of ANTESTFAC LLNR 3                          ACMS Master Unit 1.0.5B
Servicing Unit: Nns EXT. 224                        Mon Jul 22  8:07:03 1991
================================================================================

LIGHT SIGNAL SYSTEM                         SOUND SIGNAL SYSTEM
 0000 00/00/00 Main Failed                   Main Normal On
 0853 06/21/91 Emergency Failed              0853 06/21/91 Fog Detector Fail-safe

RADIOBEACON SYSTEM                          POWER SYSTEM
 Primary Online                              0926 07/17/91 System Status Unknown

SECURITY SYSTEM                             COMMUNICATION SYSTEM
 Normal                                      Normal

CLOCK SYSTEM
 Normal

STATUS|CONTROL|MODULES  |    |    |  DIR  |    |CONFIG
```

Figure 4-3

Status Display

```
Status of REMOTE LLNR 25                            ACMS Master Unit 1.0.5B
Servicing Unit: Nns EXT. 224                        Mon Jul 22  8:10:47 1991
================================================================================

COMMUNICATION SYSTEM
 Normal

              +----------------------------------+
              | NO STATUS INFORMATION AVAILABLE  |
              |  INTERROGATE REMOTE UNIT FIRST   |
              +----------------------------------+

STATUS|CONTROL|MODULES  |    |    |  DIR  |    |CONFIG
```

Figure 4-4

Status Display Before Initial Interrogation if one of the fog horns fail. The sound signal's controlling source is also displayed, "Fog Detector Controlled" or "Watchstander Controlled", depending on the way the Remote Unit configuration is setup. A Fail-safe message may be indicated for fog detector controlled sound signals.

c. Radiobeacon System. Indicates the status of the continuous operation radiobeacon, and whether primary or secondary transmitter is on-line; does not apply to DGPS radiobeacons (DGPS has own control system).

d. Power System. Displays the status of primary and secondary power. If there is a backup generator the date and time of the last engine exercise is also displayed.

e. Security System. This displays the status of the fire, intrusion, and flooding alarms.

f. Communication System. If the Master Unit fails to communicate after three attempts with a Remote or Transfer Unit a communication alarm occurs. This alarm is cleared after successful communications with the same Remote or Transfer Unit.

g. Spare Inputs. There are ten spares available for a Remote Unit and eight spares for a Transfer Unit (LEACMS Remote Unit contains two spare inputs). These spares are available for whatever input the servicing unit may want to monitor. Several of these spares are automatically setup when an LNB with a position monitor is specified under the Remote Unit setup menu:

(1) Off Station Warning. This is the first indication from the LNB Position Monitor System that the LNB may be off station.

(2) Off Station Alarm. This is the second indication from the LNB Position Monitor System that the LNB may be off station.

(3) NUC Active. This signal is originated from the Light System Controller (LSC) when the Not Under Command (NUC) lights are activated. After a watchstander gets the Off Station Warning and alarm, a signal can be sent to the LSC to activate the NUC lights. If this signal is successfully received and executed, the NUC Active On message is displayed on the LNB's status screen.

2. CONTROL (F2 Key). This function key is used to gain access to the control commands available for the

highlighted unit. Since the Master Unit and Remote/Transfer Unit command sets are different, they will have different displays (Figures 4-5 and 4-6, respectively).

a. Remote Interrogation. This command is used to request updated status information from a Remote or Transfer Unit. The updated information can be displayed using the STATUS key in the Directory Display. If there is a new alarm received during the interrogation, then the alarm screen is displayed and the terminal will beep until the alarm is acknowledged by the watchstander. An alarm is acknowledged by pressing any key.

b. Send Phone Number. This command is used for units communicating via dial-up modems only. It is not available to non-controlling (secondary) Master Units. A password is needed to access this function. This command sends a new Master Unit phone number to the ACMS Transfer/Remote.

c. Audiovisual Reset. This command is used with Remote Units to perform an audiovisual reset. This resets the light and sound signal equipment being monitored by the ACMS or LEACMS Remote Unit via the Audiovisual Controller (lighthouse), Solar Aid Controller II (solar-powered lighthouse), or the Light System Controller (LNB) at the remote site.

d. Sound On/Sound Off. If requested during system setup (via the Configuration Directory) the operator has the ability to turn the sound signal on and off remotely.

e. Radiobeacon On/Radiobeacon Off. Used to turn the radiobeacon on and off remotely.

f. Radiobeacon Reset. Used to reset the radiobeacon remotely.

g. Auto Radiobeacon Time Set. This command is used to tell the Remote Unit to use its automatic radiobeacon timing set routine. The Remote Unit clock is used as the time reference.

h. Standby Eng/Gen Exercise. Used to start the generator exercise routine via the engine controller (Lighthouse Power Controller or 9985 Engine Controller). This applies only to Remote Units with generator backups.

i. Position Monitor Reset. This control function is used for LNBs only. It currently has no affect on the LNB operation.

```
Control of MASTER                                  ACMS Master Unit 1.0.5B
Servicing Unit: NS EXT. 224                        Wed Jan 22 13:42:31 1992
==============================================================================

                              COMMANDS

      Remote Interrogation All           Set Time/Date
      Send Primary Phone No. to All      Send Secondary Phone No. to All
      Turn On All Status Forwarding

              Press ↑,↓,←,→ to select a command
              Press <GO> to execute a command
              Press <CANCEL> to abort

STATUS|CONTROL|MODULES    |    |    | DIR    |    |CONFIG
```

Figure 4-5

Master Unit Command Set

```
Control of ANTESTFAC LLNR 3                        ACMS Master Unit 1.0.5B
Servicing Unit: Nns EXT. 224                       Mon Jul 22  8:15:55 1991
==============================================================================

                              COMMANDS

      Remote Interrogation               Audiovisual Reset
      Sound On                           Sound Off
      Radiobeacon On                     Radiobeacon Off
      Radiobeacon Reset                  Manual Radiobeacon Timing Set
      Standby Eng/Gen Exercise           Turn On Status Forwarding

              Press ↑,↓,←,→ to select a command
              Press <GO> to execute a command
              Press <CANCEL> to abort

STATUS|CONTROL|MODULES    |    |    | DIR    |    |CONFIG
```

Figure 4-6

Remote Unit Command Set

j. NUC Activate On/Off. This LNB-only function is used to command the LSC to turn on the NUC Lights when the buoy is determined to be off station or adrift.

k. Spare Output Control Modules. There are three spare output control modules for a Remote Unit and eight spares for a Transfer Unit. The spare modules can be considered on/off switches at the lighthouse/LNB that are controlled remotely. Each spare module used has an On and Off command. For instance, if "Coffee Pot" is entered then two Commands are generated, Coffee Pot On and Coffee Pot Off. LEACMS Remote Units contain only one spare output.

3. MODULES (F3 Key). This function key is used to display the input modules as they actually appear at a Remote or Transfer Unit site (see Figure 4-7). If the input is active (on) the LED at the site is on, indicated by an asterisk (*). If the input is inactive (off) then there is no asterisk and the LED at the site is off.

4. DIR (F7 Key). This key is used to return the operator to the main Directory Display from the STATUS, CONTROL or MODULES displays.

5. CONFIG (F10 Key). This key takes the operator into the Configuration Directory.

```
Status bits for ANTESTFAC LLNR 3                        ACMS Master Unit 1.0.5B
Servicing Unit: Nns EXT. 224                            Mon Jul 22  8:21:02 1991
================================================================================

                         STATUS OF INPUT MODULES:

           00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15
                           *  *                 *
           16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

           00 Secondary Lamp                  16 Sound Commanded Off
           01 Primary Lamp                    17 Flooding
           02 Light Status Normal             18 Light Commanded Off
           03 Emergency Light On              19 RACON Failed
           04 Sound Secondary                 20 Radiobeacon Secondary
           05 Sound Primary                   21 Radiobeacon Failed
           06 Sound Status Normal             22 Spare Input #1
           07 Emergency Sound On              23 Spare Input #2
           08 Primary Power Online            24 Spare Input #3
           09 Primary Power Fail              25 Spare Input #4
           10 Secondary Power Online          26 Spare Input #5
           11 Secondary Power Fail            27 Spare Input #6
           12 Fog Detector Failsafe           28 Spare Input #7
           13 Fire                            29 Spare Input #8
           14 Intrusion                       30 Spare Input #9
           15 Obstruction Light On            31 Spare Input #10

STATUS|CONTROL|MODULES      |       |       |  DIR       |         |CONFIG
```

Figure 4-7

Modules Display

CHAPTER 5 RADIOBEACONS AND RACONS

A. General. Conversion of radiobeacon-equipped lighthouses to solar power can only be achieved when the radiobeacon can be relocated to another site or discontinued. Since radiobeacons are rarely popular aids to navigation nowadays, discontinuing them is increasingly acceptable to the mariner. Consequently, the population of radiobeacons will be shrinking dramatically, with the final total being used almost exclusively as components of Differential GPS. The DGPS applications of radiobeacons will occur in an availability, demand and maintenance support culture more akin to standards for Loran C service than for lighthouses and radiobeacons. Standards and equipment configurations for DGPS are not discussed in this Guideline.

When a radiobeacon is removed as part of the conversion of a lighthouse to solar power, a RACON is frequently installed or retained to maintain at least a modest all weather signal at the site. This chapter provides planning information about radiobeacons and RACONs when the lighthouse will retain conventional radiobeacon service, or when it is necessary to establish or retain RACON service as a part of a solar powered signal array. Radiobeacon and RACON system description, performance standards and maintenance requirements are covered in detail in COMDTINST M10550.25, Electronics Manual.

B. Radiobeacon Equipment. The servicewide standard solid state radiobeacons are manufactured by Nautel Maine, Inc. They are available in three basic sizes designated: NX250BD, NX1000BD, NX4000BD. Their respective power output levels are 62.5, 250 and 1000 watts adjustable.

1. The frequency range of the Nautel NX-series of radiobeacons is from 190KHz to 325KHz. Each radiobeacon has a dual RF carrier system. Their frequencies are set 1020Hz apart. One of the RF carriers is modulated by a Morse Code beacon identification signal.

2. The RF signal is generated by two identical exciters. Only one is used during normal transmission. Their purpose is to serve as ocsillators and provide dual RF carrier signals to the power amplifiers. They are used in conjunction with keyers, circuit boards located in each exciter, which furnish the gating signal to the exciter in the form of Morse Code for identification purposes. One RF carrier transmission is modulated by Morse Code and the other is unmodulated.

C. RACON Equipment. The SeaBeacon 2 RACON provides the mariner precise navigation information in the form of a coded trace on the radar screen that can readily be identified as specific to a particular RACON. The coded trace identifies and fixes the position of the RACON with respect to other targets. When used in conjunction with navigation charts showing the identity and location of the RACON, this trace aids in the correlation of other targets with their chart markings. Thus oriented, the mariner is able to achieve vessel positioning in all weather and visibility conditions.

1. The SeaBeacon 2 RACON is an all-weather aid to marine navigation that operates in response to radar pulses. The RACON is a form of transponder in that it receives a radar pulse from an interrogating radar and replies to that pulse with a coded response. The presence of that response on the radar display provides the mariner precise information regarding the identity and location of the RACON. The RACON can be used to provide range and bearing information to nearby vessels and to vessels that are up to 15 nautical miles away.

2. The SeaBeacon 2 RACON is frequency agile, which means that it can respond at the same frequency as the pulse from the interrogating radar. Moreover, the length of the coded RACON response on the radar display is scaled to be proportional to the radar pulsewidth. Digital signal processing techniques employed in the SeaBeacon 2 design enable the RACON to reply to several hundred vessels at the same time.

CHAPTER 6. PROJECT PLANNING

A. General. This chapter outlines the requirement for a premodernization survey by an engineering party to plan major structure repairs and preservation, to determine prefabricated or control volume requirements and equipment locations, and to plan security measures and installation, or major repair of boat or personnel landings or helicopter pads. If the property is historic, the planning of repairs must include consultation with historic preservation interests and should conform to the Secretary of Interior's Standards and Guidelines for Archeology and Historic Preservation.

B. Prerequisites. Prior to commencement of a premodernization survey, such determinations as equipment category, main signal equipment to be used, disposition of station structures and contents, and selection of routine maintenance transport vehicles should be made.

1. Survey Team. A project engineer should be designated and should lead the survey team since they will normally prepare the Project Development Submittal (PDS). A premodernization survey team should consist of the following members:

   a. A civil engineer--to evaluate structural soundness of existing structures, to plan preservation of retained structures, to plan foundations for prefabricated containers, to inspect and evaluate existing service vehicle facilities (such as boat landings or helicopter platforms) or to plan new ones, to determine the best location of the solar array with an unobstructed Southern exposure, and to plan submarine cable protection;

   b. An electrical engineer familiar with A/N hardware--to evaluate existing equipment, to inspect existing wiring and power systems to determine if replacement is required, to plan station electrical ground (as discussed in Chapter 7), and to plan location of main light and sound signal emitters;

   c. A mechanical engineer--to inspect the existing fuel system and power plant if engine-generators will be needed and to inspect weight-handling equipment (see Enclosure (2) for standard equipment weights); and,

   d. An electronics engineer, if radiobeacon or monitor equipment is installed--to inspect existing equipment and plan installation of modernization equipment, to inspect the radiobeacon antenna and ground system and plan repair or replacement as needed, to determine disposal of communication equipment, to plan link antenna location or telephone line connection, and to develop necessary information for the ELECTRONALT and electronics work orders.

Some of these functions can be combined, depending on the experience of available personnel. It is recommended that a member of the district (oan) staff participate in order to prepare a comprehensive CG-3213/3213A/PDS/ELECTRONALT package for submission to Commandant (G-NSR).

2. Historic Structures. COMDTINST M11011.9, Real Property Management Manual provides guidance on appropriate actions regarding any historic structures.

3. Maintenance Planning. Chapter 8 of this manual includes recommendations on planning for maintenance personnel to service automated aids.

4. Record of Changes. The survey team should carry copies of the appropriate standard installation and interconnection drawings listed in Chapter 7 so that any necessary changes can be recorded. Change information will be required for the CG-3213/3213A/PDS/ELECTRONALT submission, and for planning material and labor requirements for installation.

C. Installation Concepts. Standard automation systems are normally to be installed in standard volumes either inside lighthouses or in prefabricated containers, as described below. An essential task of the premodernization survey team is to obtain the information from which a long-term maintenance cost comparison of each of the following three modernization alternatives can be made:

1. Replace lighthouse with prefabricated containerized system and new tower;

2. Install prefabricated container system adjacent to existing lighthouse structure; or,

3. Install standard volume system inside lighthouse structure.

    a. Prefabricated Containers. Prefabricated fiberglass containers can be delivered with molded-in standard equipment foundations, wire raceways, and a power distribution panel. Installers must mount and interconnect standard equipment in signal-control containers and check out the system before delivery to the aid. In some cases, existing equipment (such as radiobeacons at the aid) will have to be installed after delivery of the container. See Enclosure (2) for weight of outfitted shelters, less dunnage.

b. Lighthouse Standard Volumes. Standard volumes inside lighthouses essentially duplicate the physical measurements and arrangements of standard systems in prefabricated containers. Compartments with well-insulated bulkheads and overheads conforming to the dimensional and volume limits of Table 6-1 are erected inside lighthouses.

(1) Standard Drawing 130109 and (Chapter 7) show the standard physical arrangements of components for Categories I, II, and III signal control systems. Since components in the less complicated Category IV system are generally only connected to power, and can be installed in the weather, system layout is not critical and components can be wall-mounted in any convenient location on interior walls.

(2) Standard Drawing 130107 shows the arrangement of components for the standard prime power engine-generator system. Doors can be relocated to conform to existing bulkhead penetrations inside of the light structures.

(3) Standard Drawing 130108 shows the arrangement of components for the standard standby power system.

D. Structures.

1. Inspection Survey. The survey team must inspect all structures on the aid and determine whether they will be retained or razed. Repair and preservation requirements for structures that will be retained must be documented. Structures not needed after modernization should be scheduled for demolition if they are not designated as historic. If they are historic, appropriate consultation with historic preservation interests is necessary. Disposal of demolition debris must be planned.

2. Ventilation. All structures that remain shall be made weather resistant, but adequate ventilation must be provided to minimize interior condensation and the resultant damage to electronic equipment. Screened ventilation openings near the top and bottom of each structure will usually produce sufficient convective airflow to handle moisture problems and hydrogen buildup. Consult Chapter 7 for specific battery ventilation requirements. Chapters 23 and 25 of the ASHRAE guide, on condensation and natural ventilation, can be of assistance. In very difficult moisture situations, power ventilation should be used if commercial power is available.

a. Where ventilation will not sufficiently reduce moisture, interior spray-on urethane foam insulation may be useful. The cost of complete interior insulation must be carefully compared with the cost of better ventilation and the most cost-effective approach should be selected.

b. The environmental control system for prime power engine-generator systems can serve as a source of clean hot air for maintaining low relative humidity within the light structure. To accomplish this, the prime power system hot air discharge assembly must be positioned to allow it to vent into the light structure. The installation of another mixing box to allow thermostatically controlled direction of the air either into the interior of the structure or outside may be required to avoid overheating of the structure during summer months. Opening internal doors between the air exhaust assembly outlet and vents installed at the top of the tower will create a stack effect. In addition to natural removal of the warmed engine cooling air, this process allows reduction of the relative humidity inside the structure, with respect to outside air, thereby reducing the condensation and decay that occur inside poorly ventilated lighthouses.

c. Two drawbacks of this type of ventilation system are creation of a partial vacuum at the environmental control system exhaust and loss of the natural barriers presented by locked doors inside the light structure. These can both be corrected by installing screened louver inserts in the doors. This will increase security and slightly restrict air flow.

d. Basements of caisson-type lighthouses are particularly susceptible to condensation since they are surrounded by water that is invariably cooler than ambient air in the summer. The waste heat from the engine-generator will usually correct this situation. Where commercial power is the main power source at such aids, consideration may be given to installing commercially powered basement heaters.

3. <u>Modification and Preservation</u>. All unnecessary openings shall be secured. Built-up masonry or brick closures on windows and unnecessary door openings are preferred over plywood closures. If plywood is used, it should be exterior grade with exterior metal sheathing or a medium density acrylic overlay to reduce maintenance.

a. Interior work should be for preservation purposes only, unless the structure is to be retained as a historic landmark and be open to the public, in which case it should be maintained in its original state.

b. Care must be taken to prevent the station from becoming a public eyesore. Previously unpainted brick or stone should remain unpainted; previously painted masonry structures should be refinished as needed, and scheduled for future periodic repainting on the AFC-43 backlog.

4. <u>Excess Property</u>. The premodernization survey team should determine what property or structures will be excess after the station is automated. Retention of property to avoid future noise complaints about sound signals must be considered. Consult COMDTINST M11011.9 for guidance. After all factors are considered, the survey team shall prepare a Board of Survey for excess property and structures for submittal to Commandant (G-ECV).

5. <u>Security</u>. Security of unattended stations must be addressed in detail. Experience has shown that even isolated offshore aids are subject to vandalism. Steel security doors with vandalproof locks should be planned and interior doors should have locks. Security fencing should be used. Windows accessible from the ground should have glass brick installed. Intrusion alarms should be installed. The standard fire suppression system installed in the power and signal control equipment spaces provides a fire alarm input to remote monitor equipment. The survey team should determine if fire alarms are needed in other areas, including detached structures. These additional detectors can be connected to the remote monitor system along with the fire suppression system alarm contacts.

6. <u>Maintenance, Storage, and Personnel Facilities</u>. Secure space must be allowed for maintenance activities and the storage of tools and spare parts. A work bench with an installed vise should be planned for location outside the prime power engine room because of noise. The size of all maintenance and work areas will vary with the equipment installed on the aid. Provisions for holding and disposing of trash and waste engine oil must be planned. Toilet facilities must be provided. On isolated offshore aids, bunks for stranded maintenance crews may be needed along with emergency rations, fresh water, and first-aid supplies.

E. <u>Equipment Location</u>. The survey team must determine locations for all equipment and the requirements for foundations, construction materials, and interconnection wiring.

1. <u>Optics</u>. Main and emergency optics must be appropriately positioned. In some cases, dual emergency lights on opposite sides of the lantern house will be necessary, with one light operating as a slave to the other. The nominal 30 degree lamp shadow zones associated with

1000W, horizontal-swing lampchangers in omnidirectional optics must be positioned away from the mariner. Although new rotating optics are weatherproof, they are small enough for installation in most lantern houses. The old lantern houses offer shelter for servicing personnel, corrosion inhibition, and wind loading protection; however, installation in lantern houses reduces light intensity by an average of 12 percent.

2. Sound Signals. As part of a solarization project, sound signals are often converted from controlled operation to continuous operation. Furthermore, while most 120VAC sound signals have directional emitters, standard 12VDC sound signals have omnidirectional emitters. These changes are normally mitigated by a reduction in the sound intensity. The Survey Team should take into consideration the impact of continuous operation on adjacent residential areas when preparing the PDS. When necessary, 12VDC emitters may be plugged to provide a directional emitter. Chapter 2 of this manual provides additional guidance on sound signal control.

3. Fog Detector. Since it may be impractical to place a fog detector within the operational area for which sound signal warnings are required, the goal should be to place it so that measurements are satisfactorily representative of the area. Installation inside a structure, with the transmitter and receiver tubes penetrating the structure, can provide satisfactory performance. The best way to determine the optimum location is to check the operation of the fog detector in various locations by visual comparison. To minimize the frequency of cleaning optical surfaces, fog detectors should be mounted so as to orient the projector and receiver windows away from prevailing winds carrying salt spray or dust. Experience has shown that several trial locations may be required to achieve satisfactory sound signal control. Proper evaluation of each location may take months.

   a. Videograph B Fog Detector. In order to avoid damage to the photodiode, the Videograph B should not face the rising sun or setting sun. The receiver (upper tube shield) should be pointed slightly upward to avoid ground reflections.

   b. VM 100 Fog Detector. The VM 100 Fog Detector should be installed on a concrete pad such that it points between North Northwest (NNW) and North Northeast (NNE) (equivalent to ± 22.5 degrees of True North). The pedestal should be leveled such that the front surface of the pedestal is 90 degrees to the plane of the ground (+1.0 degree, -0.0 degree). Locate the unit so that no obstruction such as buildings, towers, etc. are in front of the unit.

4. Air Discharge and Intake. Cooling air discharge from the prime power system should be positioned downwind from prevailing summer winds if not vented into the light structure. The air intake on the other end of the container should be above or sheltered from winter icing. Penetration locations into the interior of the structure should be identified if cooling air discharge is to be vented through the structure. The best route for combustion discharge should be determined.

5. Ventilation. Placement of the Signal Control Container should be such as to minimize icing effects on the ventilation openings. The ventilation system secures automatically below 30 degree F. A portable resistance heater should be procured locally for operation when temperatures are subfreezing.

6. Prime Power Standard Volume. Prime power standard volumes should be low in the lighthouse structure and reasonably remote from the signal control volume so as to minimize vibration in the structure and in the signal control components. Position the prime power standard volume such that engine-generator change-out for off-station overhaul is simple. An I-beam chain hoist should be provided to lift engine-generators out of prefabricated containers; dollies may be used to roll them out of standard volumes. The prime power volume should be at a floor level accessible by installed hoists. Existing bulkheads should be used wherever possible. Standard 16 inch spacing of 2 x 4 studding will hold any standard wall-hung component, the heaviest being the sound signal power supplies, which weigh 350 pounds each. Use 1/2 inch plywood on interior surfaces, and 1/4 inch plywood on back sides. Three-inch fiberglass insulation should be installed.

7. Solar Equipment. The major consideration for solar powered aids is the location, design and construction of the solar array. The array should be located close enough to the structure where the batteries and control equipment are located to limit voltage drop. The array must be low maintenance, rugged, stable and easily serviceable by technicians. Provisions should be made for mounting the Charge Controller, Solar Distribution Box and Low Voltage Drop Kit junction box on the wall of the structure, close together to limit voltage drop. The main and standby batteries are typically rack mounted, but consideration to floor loading and electrolyte containment must be made. Wiring should be installed in conduit for neatness and protection.

8. <u>Fuel Supply System</u>. A 12 month fuel supply is highly desirable, but not mandatory. Fuel supply systems should be sized for annual refueling cycles. Tank capacity (in gallons) to sustain operation over this period can be calculated (with a 20% safety factor) by multiplying the average load of the station in kilowatts by 800. Determine if a standard daytank pump will be needed following criteria in Chapter 3.

9. <u>Antennas</u>. If possible, the radio link antenna location should be selected to protect the antenna from lightning strikes. This can be accomplished by locating corner reflector antennas beneath the lantern house eaves or whip antennas below lightning rods. This assumes that radio horizon distance will allow the lowering of antenna height.

10. <u>Radiobeacon Equipment</u>. Most existing radiobeacon services will be discontinued if they are not intended to be part of a Differential GPS service; in that event, the entire radiobeacon equipment suite and installation will be evaluated and upgraded as part of the DGPS service establishment. Otherwise, removal and disposal of the equipment should be planned and the end of the service advertised.

11. <u>System Electrical Grounds</u>. The premodernization survey team should also plan the installation for all system electrical grounds, as outlined in Section N of Chapter 7.

12. <u>Special Considerations</u>. Light station modernizations in tropical areas with high humidity and high temperature may require special consideration to avoid condensation and salt-corrosion problems in signal control volumes. Solarization of Seacoast lights typically remove one or two 1000 watt lamps (heaters) from the lantern room, causing a shift in the extent of problem condensation on the storm panes. Solutions will vary with available power and installed equipment. Contact Commandant (G-ECV) for advice on a particular station.

Table 6-1

STANDARD VOLUME DIMENSIONS

	Maximum Volume	Minimum Width	Minimum Length	Minimum Height
Prime Power Engine-Generator Room	2000 ft^3	10 ft	16 ft	9 ft
Standby Power Engine-Generator Room	1000 ft^3	8 ft	10 ft	9 ft
Signal-Control Room	1000 ft^3	8 ft	10 ft	9 ft

CHAPTER 7. INSTALLATION

A. <u>General</u>. Standard installation, interconnection, and trouble-shooting drawings and special requirements for various equipment are discussed in this chapter.

B. <u>Standardization</u>. Commandant (G-ECV) has designed and tested standard automated systems to reduce installation planning requirements, installation time, and to facilitate maintenance. All installations, regardless of their complexity, are based on standard drawings which show how to install Commandant-furnished or designated standard equipment. This chapter presents requirements for the installation of standard automated systems, assuming that all necessary equipment and material has been staged.

1. If prefabricated fiberglass containers will be used to modernize an aid, virtually all equipment should be installed in the container, interconnected, and tested prior to transporting it to the aid. Free-standing equipment, such as the ACMS, radio link, and radiobeacon, must be shored to survive transit. Batteries should be shipped separately.

2. Where containers will not be used, their size and configuration will be duplicated on the aid by construction of an equivalent standard volume inside the existing structure. Fabrication requirements for standard volumes are discussed in Chapter 6.

3. Since Category IV equipment is designed for exposed installation, it can be installed on existing interior walls, thus eliminating the need for containers or standard volumes. Equipment designed for this type of installation includes AC Flash Controllers, CG-1000 sound signal power supplies, and DC power supplies.

4. Each system component should be throughly tested shore-side to assure it will perform as intended when installed at the remote lighthouse. The cost of isolating and diagnosing equipment failures at the new and untested automated lighthouse can assume budget-threatening proportions over the simplest malfunctions. Troubleshooting in a shop environment is far preferable, if possible.

C. <u>Standard Drawings</u>. Five types of standard drawings have been developed for automated aids. Installation drawings are listed in Table 7-1. Electrical interconnection diagrams and wire running lists are shown in Table 7-2. Troubleshooting drawings are listed in Table 7-3, and include system-oriented, ladder-type diagrams of the various systems with the operating sequence of the system components. Both interconnection and troubleshooting standard drawings shall be modified as necessary to reflect the actual aid installation. Table 7-4 lists procurement drawings. Space is provided on the standard drawings for entering district revisions. Table 7-5 lists standard Solar Lighthouse Drawings. Commandant (G-ECV) can provide reproducible copies of any of the standard drawings upon telephone or letter request. As-built copies of all installation and troubleshooting drawings shall be available at the aid (laminated in plastic and posted), servicing unit, supporting base, and Civil Engineering Unit (CEU). The installation, interconnection, and troubleshooting drawings are routinely distributed to CEU engineers in 35mm aperture card format for local reproduction and distribution as needed. The procurement drawings are retained at Headquarters for use in central procurement activities. All drawings are subject to continuing review, and revisions are distributed in the same manner and format. It is very important that CEU drawing inventories be kept current and that installation and maintenance personnel work from the correct drawings.

D. Installation Standards. All wiring shall be copper, and conform to the size and insulation requirements of the standard interconnection drawings. Ground leads shall be installed as required by the interconnection drawings. Grounded metal conduit shall be used for all wiring except for that in the metal cable raceways provided in the prefabricated containers. All conduit outside the power and signal control spaces shall be PVC-coated rigid steel. Rubber matting shall be placed on the floor of the signal control space, as required by COMDTINST M10550.25, Electronics Manual.

E. Operational Checkout Procedure. Before a modernization project is considered complete, it must pass an operational test. This test shall be performed in accordance with a Commandant (G-ECV) approved Operational Checkout Procedure (OCP). Sample OCPs are provided in Enclosures (3) and (4) for 120VAC and Solar 12VDC systems, respectively. Upon satisfactory completion of the test, a copy should be maintained by the responsible CEU office.

F. Optics. The installation of standard optics is described in the manufacturers' manuals, standard drawings, and COMDTINST M16500.3, Aids to Navigation Manual - Technical.

G. Sound Signals. The installation of standard sound signals is adequately described in the manufacturer's manual and standard G-ECV drawings, except as noted below.

1. Baffles. If a baffle will be required to reduce noise hazards or complaints, consult COMDTINST M16500.3, or Standard Drawing 130105, or contact Commandant (G-ECV) for an applicable baffle design.

2. Emergency Sound Signal. If space permits, install the emergency sound signal at least 20 feet from the main sound signal emitter and any structure. Locate the emergency sound signal as far off the sound projection axis of ELG-300 directional emitters as practical. If this is not possible, install it on top of the main sound signal emitter, using a locally fabricated adapter plate. Do not use the electrical connectors recommended in the emergency sound signal manual. Power connections should be made directly between the emergency sound signal terminal boards and the Audio Visual Controller (AVC), using the wires specified on the appropriate interconnection drawings in Table 7-2. These wires shall be run in PVC-coated metal conduit, but this shall not be the same conduit used for the main sound signal wires. The conduit shall terminate in a sealed junction box at the base of the emergency sound signal. A piece of standard No. 12 two-conductor SO cable shall be used for the power lead between the emergency sound signal and the junction box at its base. Install a 3/4 inch stuffing tube in the junction box to the SO cable entrance.

3. Adjustment of CG-1000 Current. After the sound signal system has been installed and tested, emitter current must be adjusted to provide proper range. For a 2 mile sound signal, adjust to 6A. After these adjustments have been made with the "HORN LEVEL" variac in the power supply, adjust the current monitor as described in the instruction booklet.

4. Grounding. Special instructions for grounding and shielding of main sound signal emitter power leads are contained in Section N of this chapter.

H. Audio Visual Signal Control System. On Category I, II, and III aids, the main and emergency lights and sound signals are controlled and switched by the AVC, which uses the Navaid Sensor Module to monitor all signals for proper operation and decide which to secure or operate. The AVC is wall-mounted and connected to power, the signals, and the Navaid Sensor Module, as shown in the drawings listed in Table 7-2. The Navaid Sensor Module is installed in a wall-mounted Navaid Sensor Module Panel. On Category IV equipped aids, flashing optics are controlled by the AC Flash Controller, while rotating optics and sound signals are connected directly to a power distribution panel. If a fog detector is used to control the sound signals, it is connected to the AVC in Category I, II, and III aids and directly to the sound signal in Category IV aids.

1. Audio Visual Controller (AVC). The AVC is delivered ready for installation and operation with all standard light and sound signal systems. Adjustments are provided for 125 to 2000W loads. The AVC must be jumpered for

either a flashed or rotating optic, and for the particular type of lampchanger and rotating optic being used.

a. If a flashed main light will be used, a CG-181 flasher must be installed in the AVC.

b. If the AVC is used with a DCB224 double-drum rotating optic with 1000W lamps in each drum, the main light circuit breaker (ICB3) must be replaced with a locally procured 25A circuit breaker. A Heinemann AM12MG6-25-125-5-60 or Airpax APL-1-16-1-253-M is a direct replacement of the installed 15A circuit breaker. All wiring connections and jumpers are described in the AVC manual located on the door of the AVC, or on the appropriate drawing in Table 7-2.

2. AC Flash Controller. Prior to installation of the AC Flash Controller, a CG-181 flasher must be installed and, if the light is to be daylight controlled, a Type L daylight control must be installed in the socket provided.

3. Navaid Sensor Module. Navaid Sensor Modules are installed in Navaid Sensor Module Panels for connection to the Audio Visual Controller and the ACMS. They operate on any power between +3 to +18 VDC and miniature switches for programming.

I. Radiobeacons. Unless intended to be part of a Differential GPS service, most existing radiobeacon services will be discontinued. Details of DGPS installations are described elsewhere.

J. ACMS Installation. The ACMS Remote equipment is delivered ready to install in 19 inch racks, and can be provided with or without modem, as required. Cabinets, racks, and radios are to be purchased with project funds. Installation requirements are described in the equipment technical manuals, ELECTRONALT 98-E001-85, and Standard G-ECV Drawing 130413-6000. The Navaid Sensor Module Panel should be mounted behind and adjacent to the ACMS cabinet.

K. 12VDC Battery System. The battery charger is bulkhead mounted and batteries are mounted in a free-standing rack. The charger and batteries are to be installed as shown in the applicable drawings listed in Tables 7-1 and 7-2. They must be kept clean, and adequate ventilation of the compartment is essential for safe operation.

1. After all mounting and wiring is completed, the float charge voltage must be set. Extreme care must be exercised in making this adjustment since it determines the water loss of the battery. Before attempting to make

the float charge adjustment, the electrolyte level of each cell must be checked and corrected, as necessary, according to the procedures supplied in the battery manufacturer's data sheets.

2. The battery must then be charged for a time sufficient to decrease the charging current to less than 10 A when a charging potential of 14 or more volts is applied to the battery. When the charging rate falls below 10 A, adjust the charger float setting to 14.0 to 14.5 VDC. This measurement must be made at the battery terminals. Do not use the voltmeter installed in the battery charger. Additional instructions on battery systems installation and maintenance are available in the battery charger technical manual and the battery instruction sheets furnished with the batteries.

L. Fire-Suppression System. No new fire suppression systems are to be installed as part of a standard lighthouse system, and no discharged Halon 1301 systems at lighthouses are to be recharged; instead the equipment should be removed and the Lighthouse Power Controller (LPC-if one is present) should be field wired to operate without any fire suppression system. The existing Halon 1301 fire-suppression systems may be retained in service at 120VAC lighthouses until the agent is discharged. They are to be maintained either by CG personnel who have been trained in the proper maintenance techniques at the Lighthouse Technician Course, ANC-LT, or by a local Fenwal Inc. representative. The name of the Fenwal representative nearest you may be obtained by calling 508-881-2000.

M. Power Systems. This section adds to the information contained in Chapter 3, applicable technical manuals, and standard drawings on installation of engine-generators, lighthouse power controllers, starting batteries, and fuel daytanks.

1. Engine-Generator. Engine-generators shall be installed in the location shown on the standard installation drawings. A clearance of at least 36 inches is required on all sides for servicing. Additionally, there should be a 5 foot clearance in front (engine end) for possible removal of the lube oil reservoir. The engine-generator set is delivered on a skid base with vibration mounts. No foundation is required except to install ten 5/8 inch, hold-down bolts in the holes provided in the skid base. The floor of prefabricated containers has sufficient strength to support the engine-generators. Place 2 inch long lag bolts directly into the flooring. It is not necessary to bolt into container floor beams. A lifting yoke is furnished and a 2 inch diameter hole is located on each corner of the base for towing or lifting.

a. Exhaust System. Separate exhaust piping is to be installed for each engine. The exhaust outlet shall be located on the opposite side of the light structure from the air intake. Ventilated thimbles for exhaust piping are provided in the prefabricated power containers. Mufflers are provided with the engines for exterior installation, but they can be omitted if noise will not be objectionable. If the exhaust piping is directed upward outside the standard volume, install a bottom condensation trap and drain valve. If exhaust pipe bends are necessary, use large radius elbows. The exhaust system design must be such that back pressure will not exceed 3 inches of mercury (40.8 inches of water). Exhaust pipe diameter should generally be as follows:

- 8KW--under 20 feet long, use 1-1/4 inch, over 20 feet long, use 1-1/2 inch; and
- 11KW--under 20 feet long, use 1-1/2 inch, over 20 feet long, use 2 inch.

Commandant (G-ECV) will provide air intake and exhaust hoods, dampers, and filter units. The installing unit must provide hot air discharge ducting from the engine to the point of exit from the prefabricated container or standard volume, as applicable. The locally provided ducting must include a flexible duct connection and back draft damper for each engine: these are described on Drawing 130109. The air discharge fitting provided on the engine is an 8 x 16 inch duct flange. The air discharge ducting outside the standard volume should be sized to ensure that discharge air flow is not restricted. The following are minimum air discharge duct sizes:

- Length of less than 5 feet--96 square inch area;
- 5 to 10 foot length--135 square inch area;
- 10 to 25 foot length--216 square inch area; and

(d) 25 to 50 foot length--336 square inch area.

b. Wiring. Electrical wiring shall be installed as shown on the standard drawings. The generator power output and control and sensor connections are fitted with MS type connectors. Male plugs are provided with the engine-generator. No special tools are required to assemble the connectors. Wiring shall be sized as follows:

- Starter (24VDC), No. 2/0 AWG;
- Power output (120VAC), No. 2 AWG;
- Control and sensor, No. 18 AWG; and
- Generator ground terminal, No. 6 AWG.

c. Fuel Piping. All fittings between the engine and daytank are for 5/16 inch OD copper tubing and fuel flexible hose. The engine is delivered with a 3/16 inch fuel return line connection. This connection must be fitted with an adapter to allow use of 5/16 inch tubing. Fuel piping between the daytank and fuel tanks shall be 1 inch.

2. Lighthouse Power Controller (LPC). The LPC and its transfer switch are installed as detailed in the appropriate installation drawing and technical manual. All connections to the LPC are made with MIL-SPEC style connectors which are furnished with the controller. Cable lengths and sizes are detailed on the installation drawings. These connectors and cables must be fabricated under shop conditions. Adjust the exercise period and the time delay on electrical fault shutdown as directed in the LPC technical manual.

3. 24VDC Battery System. The 24VDC battery system shall be installed as detailed in the appropriate drawing and battery charger technical manual. The installation instructions presented earlier for the 12VDC battery system apply to the 24VDC system except that the float charge shall be set at 29VDC.

N. Grounding. All system grounds shall follow National Electrical Codes. Particular attention must be paid to the grounding of engine-generators because of shock hazards and the grounding of sound signals because of radiated electromagnetic interference. A single point ground system shall be established at the ground buses of the signal control and power system container power distribution panels. These ground buses shall be tied to the station ground selected during the premodernization survey. This connection must be made with bare No. 6 AWG or larger wire, or other means with equal current carrying capability. Refer to Standard Drawings 130419, 130420, 130421, 130422.

1. Electrical grounds are installed for three reasons: to limit the voltage of circuits to ground during normal operation and to limit the amplitude of voltage peaks resulting from lightning, line surges, or unintentional contact with higher voltage lines; to prevent protective enclosures for circuits from developing a potential above ground; and to facilitate the operation of over-current

protection devices, in case of insulation failure or ground fault.

2. The path to ground from circuits and enclosures must be permanent and continuous, and must have sufficient capacity to safely carry any current which is likely to be imposed on it. Its impedance must be low enough to keep the potential of any part of the ground circuit at a very low level.

   a. Standards. Grounds and grounding systems are to be in strict accordance with the applicable sections of the National Electrical Code and the National Electrical Safety Code. Grounding shall be provided for all equipment and structures associated with electrical systems. The following three methods provide good ground connections:

      (1) Water pipe connection--the electrical system can be grounded to a water supply system, except where non metallic pipes or insulated couplings are part of the water piping system.

      (2) Ground rods--ground rods can be used either singly or in cluster. Drive the ground rods to ground-water level for effective and permanent installation. Provide for corrosion prevention by a proper choice of metals or cathodic protection. Where ground water cannot be reached, chemicals such as salt or calcium chloride should be used to improve soil conductivity.

      (3) Combination of ground methods--where the ground resistance is extremely high, water pipes and ground rods can be used in combination.

   b. Earth Resistance. Earth resistance is the resistance of soil to the passage of electric current. The earth is a relatively poor conductor of electricity compared with normal conductors such as copper wire; however, if the area of a path for current is large enough, resistance can be quite low and the earth can be a good conductor. Earth resistance can be measured by determining the effectiveness of ground grids and connections which are used with electrical systems to protect personnel and equipment, or by prospecting for good (low resistance) ground locations--that is, by obtaining measured resistance values which can give specific information about what lies below the earth's surface.

3. A standard instrument for earth resistance testing includes a voltage source, an ohmmeter to directly

measure resistance, and switches to change the instrument's resistance range. Extension wires connect four terminals on the instrument to the earth and reference electrodes. A handcranked generator supplies the required current; resistance in ohms is read from a pointer on a scale or a digital readout. The two basic test methods for earth resistance are the direct method or two-terminal test, and the fall-of-potential method or three-terminal test. Terminal designations that follow assume that standard Biddle Megger earth testers are used.

a. Direct Method Test. In the direct method, P_1 and C_1 terminals connect to the earth electrode under test; P_2 and C_2 terminals connect to an all-metallic water-pipe system. If the water system covers a large area, its resistance should be less than an ohm. The instrument reading is then the resistance of the electrode under test. With this method, resistance between the driven rod and the water system is measured. The earth electrode under test must be far enough away from the water-pipe system to be outside its sphere of influence. Distance from the earth electrode system to the water-pipe system should be about 10 times the radius of the electrode or grid to obtain a measurement within an accuracy of 10 percent.

b. Fall-of-Potential Method Test. In the fall-of-potential method or three-terminal test, the P_1 and C_1 terminals on the instrument are jumpered and connected to the earth electrode under test. The driven reference rod C_2 is placed as far from the earth electrode as practical; this distance may be limited by the length of extension wire available of the geography of the surroundings. Potential reference rod P_2 is then driven in at a number of points roughly on a straight line between the earth electrode and C_2. Resistance readings are recorded for each of the points. A curve of resistance verses distance is then drawn. Correct earth resistance is read from the curve for the distance that is about 62 percent of the total distance from the earth electrode to C_2.

   (1) Connection to Engine-Generator. Terminal B of the 120VAC output connector located on each engine-generator electric panel assembly provides a connection to the Engine-Generator set frame. The B terminals of all three power connectors (P1, P2, P3) on the power system controller are connected together internal to the controller. Terminal B of connector P on the power system controller is connected to the

single point station ground, located at the power distribution panel of the signal power distribution panel. This is generally included as part of the three-conductor power cable which connects the power and signal control systems.

(2) Other System Grounds. All equipment in the signal control container is grounded to the power distribution panel ground bus. The radiobeacon system shall be grounded to this point. The radiobeacon transmitter, coaxial cable, coupler, and antenna system shall be grounded as required by good electronic engineering practice.

(a) Any lightning rods installed shall be connected directly to the station ground. They shall not be connected to any equipment or power distribution panel ground bus.

(b) Insure that a ground strap is used to ground the sound signal power supply to the signal control container ground bus. Do not rely on a conduit to ground the various components of the sound signal system. The emitters must be grounded to the power supply by the power lead shield. Metal conduit shall be used between the emitter and power supply to route the power leads and ground shield.

O. Solar Power Systems. This section adds to the information contained in Chapter 10 COMDTINST M16500.3, Aids to Navigation Manual - Technical, and standard drawings on installation of solar arrays, local terminal boxes, PV combiner boxes, solar charge controllers, solar distribution boxes, solar aid controllers, and batteries.

1. Main Solar Array. The main solar array will be exposed to the marine environment, and, for this reason, it should be constructed of low maintenance alloys (i.e., type 6061-T6 Aluminum). Use of weathering steel (Cor-Ten), painted or galvanized steel is not advised as it will not perform as desired in a salt air environment. The array should be constructed to withstand a 100 year storm and most importantly, must provide easy and safe access to the front and rear of all solar panels. Also, the array must be installed at the desired tilt angle, facing South and unobstructed by railings, terrain, etc.

2. Local Terminal Boxes (LTBs). Local terminal boxes shall be mounted on the rear of the array as close as possible to the group of panels that it services. Connections in

the LTB shall be made using crimped (soldered, if possible) spade or spring spade lugs. Terminals shall be covered with No-Ox grease to retard corrosion.

3. PV Combiner Box. The PV Combiner Box has up to 6 inputs from LTBs which are divided into three outputs that feed the charge controller. The last two inputs are directly connected to the battery, providing a float charge. The inputs are generally divided up equally, however if 4 or 5 LTBs are used, then the last string should only contain the input from 1 LTB.

4. Solar Charge Controller (SCC). The Charge Controller is typically mounted in the lighthouse structure near the SDB and main battery. In climates where the difference of the average monthly temperature extreme exceeds 20 degrees F and drops below 50 degrees F, a Temperature Controller is installed in the Charge Controller to disable it when the battery temperature falls below 50 degrees F. Voltage settings will vary depending on location; consult with COMDT (G-ECV-3) for guidance.

5. Solar Distribution Box (SDB). Like the Charge Controller, the SDB is typically mounted inside the lighthouse structure near the Charge Controller and main battery. The SDB, however, can be mounted outside if necessary since the enclosure is weather resistant NEMA 4X.

   a. The Solar Aid Controller II (SAC II) is usually mounted inside the SDB flush against the aluminum mounting panel in the marked area. The SDB's mounting panel contains eight each 8-32 press nuts spaced appropriately to accommodate two SAC IIs. Thermal joint compound must be used between the SAC II and the SDB's mounting panel to allow for proper heat transfer.

   b. When the aid is equipped with an emergency sound signal, a normally open Solid State Relay (SSR) (Douglas Randall model K12A or equivalent) must be mounted inside the SDB flush against the mounting panel in the marked area. The emergency sound signal is then indirectly controlled by the SAC II via this SSR. A 1N4001 diode must be installed across the SSR's output terminals to protect against back-emf damage.

   c. When an aid is monitored and an LEACMS is used, four 1N4001 diodes must be installed on terminal blocks TBL1 and TBS1 according to standard drawing 140410, Category I Solar Powered Lighthouse System, to provide electrical isolation between the LEACMS and emergency signal control equipment.

6. Solar Aid Controller II (SAC II). The SAC II is usually mounted inside the SDB flush against the aluminum mounting panel in the marked area. However, if no SDB is used, the SAC II must be mounted flush against an appropriate heat-sinking metal surface. Thermal joint compound must be used between the SAC II and metal mounting surface to allow for proper heat transfer.

7. Low Voltage Drop Kit. The kit contains two junction boxes with 12 AWG wire terminated at one end to facilitate connection to the SDB and CG-6PHW, and up to 1/0 AWG wire between the boxes to limit voltage drop. The junction boxes shall be installed as close as possible to the SDB and the optic to ensure that 12 volts is applied to the main light.

8. Main Battery. The largest cells can be quite heavy, over 300 pounds; therefore, handling considerations should be made to facilitate installation. Cells should be installed on either a custom battery rack or one available from the manufacturer. Areas with siesmic activity shall use a suitably rated rack. The area beneath the cells should have a containment system equal to at least one cell's volume of electrolyte, and contain a neutralizing, absorbant material. Batteries should be installed as soon as possible after receipt. Otherwise, batteries should be stored indoors in a cool, dry area. Secondary batteries should receive a freshening charge every 6 months, or sooner, as required by the manufacturer. Installation should be in a clean, dry, level area and out of direct sunlight (to prevent individual cell heating).

   a. Transportation. Transportation to the aid site can be accomplished in the original shipping container to afford protection. Care must be exercised to avoid extensive vibration which may cause damage to the cells. Manhandling over difficult terrain may lead to damage, especially to wet cells with plastic cases. Transportation by helicopter is a viable alternative as long as the descent is controlled to prevent swinging into an immovable object, with the subsequent destruction of the cell and pollution of the eventual landing place of the electrolyte. Batteries should not be lifted by their terminal posts nor by friction type battery carriers. Lift batteries using manufacturer's supplied lifting eyes or lifting belts. Insulating material should be placed over the posts to prevent shorting due to overhead chains and hooks.

   b. Safety. Large secondary battery systems are a source of extremely high short circuit currents. Care must be exercised to prevent accidental shorting when transporting, installing and servicing them. Cells should be covered with insulating material when metallic lifting devices are used or when working overhead. Intercell connectors should be covered with a plastic, removeable wiring duct (Panduit D2.5X3LG6) after installation to prevent accidental shorting.

c. Servicing. Safety equipment such as goggles, rubber gloves, etc., should be kept on-station in a wall-mounted cabinet. Hydrometers for nickel-cadmium and lead acid batteries must be kept separate and not interchanged. An eye wash station should be installed in the event battery electrolyte is splashed into a person's eyes.

d. Ventilation. Batteries used at solar powered lighthouses will generate hydrogen gas when they are fully charged. This will occur all year long with the standby battery, and during spring through fall for the main battery. The amount of hydrogen evolved is not dependent on the type and size of battery (lead-acid or nickel-cadmium), but rather on the charging rate, number of cells and the time applied. Hydrogen concentrations of up to 3% (by volume) are non flammable, at 4-8% hydrogen will burn if exposed to an open flame or spark, and above 8% hydrogen will ignite explosively. The maximum hydrogen concentration for an enclosed space set by the Occupational and Safety Health Act (OSHA) is 1%. Hydrogen production for lead-acid and nickel-cadmium batteries can be calculated as follows:

$$C = 0.00027 \times N \times I \times 60$$

where: C is the amount of hydrogen produced in ft^3/hr;

0.00027 is the maximum hydrogen production in ft^3/min per cell per ampere charge current;

N is the number of cells;

I is the estimated float current in amps which is estimated to be 1% of the battery capacity;

60 min/hr is a conversion factor.

Knowing the amount of hydrogen produced, the amount of new air required to prevent the concentration from exceeding the predetermined level can be calculated:

$$A = C / 0.01$$

where: A is the amount of new air required per hour in ft^3/hr;

C is the amount of hydrogen produced in ft^3/hr;

0.01 represents the maximum concentration level of 1%.

Manufacturers of "Modular" rooms may be able to provide information on natural air change rate. On converted dwellings, a "tight" battery room will have an air change in about 4 hours. If venting is required, then the preferred type is a low mounted louvered vent in the door or wall and a ridge vent (to expel hydrogen trapped near the ceiling) at the highest point in the shelter.

P. Warning Signs.

1. Sound Signals. Sound signal danger warning signs shall be posted conspicuously on all aids equipped with remote or fog detector controlled sound signals. Signs shall be installed in accordance with COMDTINST M16500.3.

2. Radiation Hazards. RF radiation hazard signs shall be posted as required by COMDTINST M10550.25.

3. Cable Crossing. Cable crossing signs shall be installed on aids equipped with submarine cable.

4. No Trespassing. Standard "No Trespassing" signs shall be installed.

5. Other Hazards. Certain caution signs are required because of unique hazards on automated aids. These shall be locally painted using a yellow background and black letters. Details of these signs are below:

   a. For engine-generators:

CAUTION

MAXIMUM PERMISSIBLE DAILY EXPOSURE (MPDE) IS 1 HOUR.
USE EAR PLUGS OR MUFFS IF EXPOSURE LONGER THAN MPDE.

   b. For batteries:

CAUTION

BATTERY CONTAINS CAUSTIC POISON. DO NOT TAKE
INTERNALLY OR ALLOW CONTACT WITH SKIN.

CAUTION

HYDROGEN GAS. EXTINGUISH SMOKING MATERIALS. ALLOW ENCLOSURE TO VENTILATE FOR 5 MINUTES BEFORE ENTERING.

c. For fire-suppression systems:

CAUTION

FIRING SQUIB MAY BE ACTIVATED BY RF. SHUT OFF RADIO EQUIPMENT DURING DISASSEMBLY OF FIRE-SUPPRESSION SYSTEM.

d. For standby or secondary engine-generators:

CAUTION

THIS ENGINE REMOTELY CONTROLLED. PUT THE LIGHTHOUSE POWER CONTROLLER IN THE OFF POSITION AND DISCONNECT STARTER POWER PRIOR TO SERVICING.

6. Standard ATON Warnings. Standard aids to navigation warning signs shall be posted on all exterior doors on the light structure, prefabricated containers, and any retained structures. It is suggested that the phone number of the responsible group commander be displayed below the sign. These signs are available on the term contract for signs, legends, and emblems. If a site has been subject to vandalism, post a sign stating that the site is equipped with a remote intruder alarm.

7. Information for Stranded Mariners. To assist potential SAR cases, instructions for stranded mariners as related to communications available, first-aid supplies, and emergency rations should be prominently posted. This will also ease problems that may be faced by the maintenance force as a result of accidents or being forced by weather or other causes to remain for prolonged periods at the automated unit.

TABLE 7-1

Standard Aids to Navigation Installation Drawings

Number	Rev	Title
130103-1		FA232 Sound Signal 12VDC Current Detecting Device Installation
130104		3 Mile Fog Detector Installation
130105-1		Standard Sound Signal Baffle for ELG-300/02
130105-2		Standard Sound Signal Baffle for ELG-500/04
130105-3		Standard Sound Signal Baffle for FA-232
130107	B	Prime Power Standard Volume Equipment Layout Installation 10 X 16 X 10
130108		Standby Power Volume Equipment Layout Installation 10 X 16 X 10
130109	B	Signal Control Volume Equipment Layout Category I Installation 8 X 10 X 10

TABLE 7-2

Standard Aids to Navigation Interconnection Drawings

Number	Rev	Title
130401	B	DCB-224 Rotating Optic with Emergency Light
130402	D	Rotating Optic DCB-24 with Emergency Light
130405	B	Flashed Optic 1000 Watt with Emergency Light
130407		FA-251-AC Rotating Optic With Emergency Light, Interconnecting Diagram With Wire Running List
130408	B	Single CG-1000 Sound Signal with Emergency Sound, Interconnecting Diagram With Wire Running List
130409	A	CG-1000 Sound Signal System without Emergency Sound, Interconnecting Diagram With Wire Running List
130410	C	Dual CG-1000 Sound Signal System with Emergency Sound, Interconnecting Diagram With Wire Running List
130413-6000		ACMS Monitor Group, Interconnection, Lighthouse
130414	A	AV-Controller Navaid Sensor Module Panel and Fog Detector, Interconnecting Diagram With Wire Running List
130415		120VAC Range Light Power System
130418-1	E	Prime Power Volume Engine/Generator System, Interconnecting Diagram With Wire Running List
130418-2	F	Standby-Power Volume Engine/Generator System, Interconnecting Diagram With Wire Running List
130419	C	Power Distribution Signal Control System, Interconnecting Diagram With Wire Running List
130420	F	Prime Power Distribution, Interconnecting Diagram With Wire Running List
130421	F	Standby Power Distribution, Interconnecting Diagram With Wire Running List
130422	D	Standby Aid to Navigation 115V-AC and 24 & 12VDC Power Distribution System Diagram
130423		Environmental Control Units, Interconnecting Diagram With Wire Running List
130434	A	Dual FA-232 Main Sound Signal without Emergency Sound, Interconnecting Diagram
130435	A	Single FA-232 Main Sound Signal System With Emergency Sound, Interconnecting Diagram
130436	A	Quad 12VDC Main Sound Signal With Emergency Sound, Interconnecting Diagram
130440		NX250BD Radio Beacon system Power and RCMS, Interface, Interconnecting Diagram With Wire Running List
130441		NX1000BD Radio BeaconSystem Power and RCMS, Interface, Interconnecting Diagram With Wire Running List
130442		NX4000BD Radio BeaconSystem Power and RCMS, Interface, Interconnecting Diagram With Wire Running List

TABLE 7-3

Standard Aids to Navigation Troubleshooting Drawings

Number	Rev	Title
130701	B	DCB224 Rotating Optic, Troubleshooting Diagram
130702	A	DCB24 Rotating Optic with Emergency Light, Troubleshooting Diagram
130705	B	Flashed Optic (1000 Watt) with Emergency LightTroubleshooting Diagram
130706	A	Flashed Optic (250 Watt) with Emergency Light Troubleshooting Diagram
130707		FA-251-AC Rotating Optic With Emergency Light, Troubleshooting Diagram
130708	A	CG-1000 Sound System Single SystemTroubleshooting Diagram
130709		Single CG-1000 Main Sound Signal without Emergency Sound, Troubleshooting Diagram
130710	C	Dual CG-1000 Sound Signal System with Emergency Sound, Troubleshooting Diagram
130718-1		Engine Controller System 130719 B Daytank Assembly
130719		Daytank Assembly System, Troubleshooting Diagram
130734		Dual FA-232 Sound Signal without Emergency Sound, Troubleshooting Diagram
130735		Single FA-232 Main Sound Signal with Emergency Sound Signal, Troubleshooting Diagram
130736		Quad 12VDC Main Sound Signal With Emergency Sound, Troubleshooting Diagram

TABLE 7-4

Standard Aids to Navigation Procurement Drawings

Number	Rev	Title
130901	C	Standard Daytank Assembly
130902-1	D	Environmental Control System Prime Power Air Intake Unit Assembly
130902-2	C	Environmental Control System Prime Power Air Exhaust Unit Assembly
130902-3	A	Environmental Control System Prime Power Hoods (Details)
130902-4		Prime Power Environmental Control System, Air Exhaust Hood Assembly
130902-5		Prime Power Environmental Control System, Damper Hood Assembly
130904	A	GCF-RWL-2098, Audio/Visual Controller (21 Sheets)
130905		GCF-RWL-2106, AC Flash Controller (7 Sheets)
130909-1		Prime Power Container (10' x 16' x 9'3"), Basic Outfitting
130909-2		Prime Power Container, Monorail Details
130912	A	Signal Control Volume (10' X 16' X 9' 3"), Basic Outfitting
130913	B	DC Distribution Panel Assembly 12VDC and 24 VDC
130914	A	Emergency Power Entrance Assembly
130915	B	Fire Suppression System Modification
130919	A	Standard High Endurance Engine/Generator Set, 4kw (13 Sheets)
130920	A	Standard High Endurance Engine/Genertor Set, 8kw (13 Sheets)
130921	A	Standard High Endurance Engine/Generator Set, 11.2kw (13 Sheets)
130922		GCF-RWL-2423 ATON Power supply
130923		Range Beacon Controller
130923-XXXX		ACMS (75 Sheets)

TABLE 7-5

Standard Solar Aids to Navigation System Powered Drawings

Number	Rev	Title
140401	B	Category I Solar Powered Lighthouse System
140402	A	Category II Powered Lighthouse System
140408	C	Day/Night Range Light System, 12VDC, 100 watt
140410	D	Category I Solar Powered Lighthouse System (Northern Latitude)
140415		12VDC Solar Range Light Power System

CHAPTER 8. PROCUREMENT AND MAINTENANCE

A. General. This chapter provides a listing (including cost) of components needed to modernize aids, suggests a maintenance organization, and outlines support details for certain equipment.

B. Procurement. Commandant (G-ECV) centrally procures and stocks most of the standard components required to modernize major aids. Recurring procurements of this equipment are scheduled after review of the annual district and CEU modernization and solarization planning updates. No further action other than periodic update submission is needed to insure procurement.

1. Centrally procured equipment for approved lighthouse projects can be obtained by letter request to Commandant (G-ECV). The remaining equipment and materials required are obtained by local purchase.

2. Tables 8-1, 8-2, 8-3, and 8-4 are a comprehensive listing of equipment and material needed to assemble standard systems defined by drawings listed in Chapter 7. Approximate costs are included for use in computing total project cost estimates.

C. Maintenance. Maintenance of automated aids consists of periodic on-site checks to insure that they are operating correctly; scheduled maintenance trips to perform preventive maintenance of the equipment, structures, and grounds; and responding to monitored or reported discrepancies and outages. A three-level maintenance organization is suggested to assist districts and groups in carrying out their maintenance responsibilities. COMDTINST M16500.6, Lighthouse Maintenance Management Manual, provides information, principles, policies, and requirements for district commanders, group commanders, and aids to navigation teams to maintain lighthouses, which are part of the Short Range Aids to Navigation Program.

D. Support. The standard systems and equipment referred to in this guide are described in COMDTINST M16500.3, Aids to Navigation Manual - Technical, and standard G-ECV drawings listed in Chapter 7. Each component usually has a technical manual or data sheet shipped with it for use by the installers and maintenance units.

A major aids to navigation maintenance training course (ANC-LT) has been implemented at the NATON School to train military and civilian personnel to assume responsibility for maintenance of automated aids, including ACMS and other selected electronics systems. Companion courses ANC-FD & ANC-RB cover fog detectors and radiobeacons for ETs. Course ANC-M covers diesel engine overhaul for MKs.

Table 8-1

Power System Equipment listing

Equipment	Source	1994 Cost (K$)
Standard 8KW, High-Endurance Engine-Generator	G-ECV	12
Standard 11KW, High Endurance Engine-Generator	G-ECV	13
Lighthouse Power Controller	G-ECV	11
24V Battery Charger	G-ECV	2
24V, 100 AH NiCad Engine Start Battery and Rack	Local	2
Environmental Control System	G-ECV	10
Automatic Daytank	Local	4
Prefabricated Prime Power Container	G-ECV	26
Wiring and Ducting	Local	4
Material to Construct Standard Volume	Local	3
24V Power Distribution Panel for Standard Volume	G-ECV	0.6
Environmental Control System Components for Standby Power System	Local	1
Engine-Generator Field Spares Kit	G-ECV	2
11KW Base Spares Kit	G-ECV	4
8KW Base Spares Kit	G-ECV	3
Lighthouse Power Controller Spares Kit	G-ECV	2
12VDC Power Supply	G-ECV	1
10W Solar Panel	SUPCEN	0.2
20W Solar Panel	SUPCEN	0.2

35W Solar Panel	SUPCEN	0.3
Solar Distribution Box	G-ECV	1.5
Solar Charge Controller	G-ECV	1.6
PV Combiner Box	G-ECV	0.5
Local Terminal Box	G-ECV	0.2
Multiarray Controller	G-ECV	1.6
43W High Density Solar Panel	G-ECV	0.2
Siemens M75 or Solarex SX-38MM solar panel Auxiliary solar panel	Local	0.3
Exide EI and FHGS main battery	Local/GSA Contract	3 to 6
SAFT-Nife ED series NiCad battery	Local	3

Table 8-2

Signal Control System Equipment listing

Equipment	Source	1994 Cost (K$)
Audio Visual Controller	G-ECV	3
AC Flash Controller	G-ECV	1.2
Navaid Sensor Module	G-ECV	0.3
Navaid Sensor Module Panel (Empty)	G-ECV	0.4
12V Battery Charger	G-ECV	0.9
12V NiCad Batteries (80, 240, or 400 AH) and Rack	Local	1 to 3
Prefabricated Signal Control Container (Small)	G-ECV	20
Prefabricated Signal Control Container (Large)	G-ECV	26
Wiring	Local	3
Material to Construct Standard Volume	Local	3
12VDC Power Distribution Panel for Standard Volume	G-ECV	0.5
Fog Detector	G-ECV	5
Solar Aid Controller II	G-ECV	0.1

Table 8-3

Signal System Equipment Listing

Equipment	Source	1994 Cost (K$)
DCB24 Rotating Optic	G-ECV	10
DCB224 Rotating Optic	G-ECV	14
24 Inch Range Lantern	G-ECV	4
14 Inch Range Lantern	G-ECV	2
300mm/250mm Lantern	Local	0.6
CG4P-120 Lampchanger	Tideland	0.6
FLAC-300	Tideland	0.5
CG-1000 Sound Signal	G-ECV	20
FA-232 Sound Signal (Single)	API	4
FA-232 Sound Signal (Dual)	API	9
SA-850 Sound Signal	API	7
Nautel Radiobeacon	EECEN	10

Table 8-4

Aid Control and Monitor System (ACMS) Equipment Listing

Equipment	Source	1994 Cost (K$)
ACMS Master Unit (CGSW)	Local	10
ACMS Remote Unit	EECEN	10
RU Spares Kit	EECEN	4
ACMS Transfer Unit	EECEN	9
Low Energy ACMS RU	G-ECV	4
Range Light Controller	G-ECV	10

TABLE 8-5

Major Aids to Navigation Equipment Support

Equipment	Parts Support
Standard High-Endurance Engine-Generator	Spare parts kits provided, replenish commercially
Lighthouse Power Controller	Spare parts kits provided, replenish commercially
Battery Chargers	Spare parts kits provided, local purchase from manufacturer
NiCad Batteries	Local purchase from manufacturer
Environmental Control System	Local purchase from component manufacturer
Automatic Day Tank	Local purchase from component manufacturer
Audio Visual Controller	Local purchase from component manufacturer
AC Flash Controller	Local purchase from component manufacturer
Navaid Sensor Module	Spare provided, mandatory turn-in to EECEN
Videograph B Fog Detector	Spare parts provided, EECEN depot level support available
FA-251-AC Rotating Beacon	Local purchase from manufacturer
DCB24/224 Rotating Beacon	Major components from SUPCEN; remainder local purchase from manufacturer
FA-232 Sound Signals	EECEN
SA-850 Sound Signals	EECEN
CG-1000 Sound Signals	EECEN
ACMS Equipment	Spares provided, EECEN depot level support

GE Radio Link	Spares provided, EECEN depot level support
EF Johnson Radio Links	Local purchase from manufacturer
Nautel Radiobeacons	Spare parts provided, EECEN depot level support available
RACON	Unit replacement, mandatory return to EECEN

ATON STANDARD EQUIPMENT MANUFACTURERS' NAME AND ADDRESS LISTING

DOD CODE	MANUFACTURER'S ADDRESS	STANDARD EQUIPMENT
01276	**Aeroequip Corporation** 1225 W. Main Street Van Wert, OH 45891	Hose and couplings on Lister engine
	Alcad Batteries 73 Defco Park Road North haven, CT 06473	12V & 24V NiCad battries
01767	**American Air Filter Company** 215 Central Avenue Louisville, KY 40201	Air filter for environmental control unit
	Andrew Corporation 5601 Gardner Avenue P.O. Box 1039 Kansas City, MO 64141	Power and signal Fiberglass shelter
	Automatic Power, Inc. P.O. Box 230738 Houston, TX 77223-0738	120VAC sound signals, 12VDC sound signals, FA-251-AC beacon, Flashtubes
97520	**Basler Electric Company** P.O. Box 269 Route 143 Highland, IL 62249	Voltage regulator on Lister engine-generator
10741	**Carlisle & Finch Company** 4562 West Mitchell Avenue Cincinnati, OH 45232	DCB-24 and DCB-224 rotating optics, CG-2P1000 lampchanger, 24 inch range light
14704	**Crydom Controls** Div. of International Rectifier, Dept EM 1521 Grand Avenue El Segundo, CA 90245	Relays in controllers
16327	**Dayton Electric Manufacturing Company** Dayton, OH	Exhaust fan for signal-control shelter, blower unit for environmental control unit.

16764	**Delco-Remy Division** P.O. Box 2439 Anderson, IN 46011	Starter motor, Lister engine
	Douglas Randall 6 Pawcatuck Avenue Pawcatuck, CT 06379	Solid state relays in controllers, SDB
	E.F. Johnson Company 438 Gateway Blvd. Burnville, MN 55337	Telemetry radio equipment for ACMS/RLC comms link
	Exide Corporation 9055 Guilford Road Columbia, MD 21045-1879	Main batteries, Lead-Acid, EI & FHGS
73168	**Fenwal** 400 Main Street Ashland, MA 01721	Halon fire suppression systems
	Fermont Division 141 North Avenue Bridgeport, CT 06606	6.5 & 10KW E/G sets, enginer controller
	Fidelity Technologies Corp. 2501 Kutztown Road Reading, PA 19605	Videograph B & VM100 fog detector, LPC, BPC, LSC-1, MAC
08771	**General Electric Company** Mobile Radio Department P.O. Box 4164 Lynchburg, VA 24502	Aid dual transceiver, master dual transceiver radio repeater
17479	**Honeywell** Honeywell Plaza Minneapolis, MN 55408	Damper with damper control system for for environmental control unit
	Inertial Motors Corporation 280 North Broad Street Doylestown, PA 17901	Emergency generator for solar power lighthouses
	Jimal Intergration, Inc. 23 Howard Avenue Lancaster, PA 17602	SDB, PVCB, LTB, LVDK
	Kim Hotstart Manufacturing 5724-T E. Broadway P.O. Box 42 Spokane, WA 99210-0042	Crankcase heaters for engine-generators

	King Electronics, Inc. 2221 Valetta Street Philadelphia, PA 19124	AC flash controller
36156	**Lima Electric Co., Inc.** 200 East Chapman Road Lima, OH 45801	Generator in Lister-Lima engine-generator
	Lister Diesel, Inc. P.O. Box 386 555 E. 56 Hiway Olathe, KA 66061	6.5, 8, 10, & 11KW E/G sets, engine
	Nautel Maine, Inc. Target Industrial Circle Bangor, ME 04401	Radiobeacons NX-Series
76714	**Nelson Electric** Division of Solar Basic Industries, Box 726 4041 S. Sheridan Road Tulsa, OK 74101	Cable penetrator for power signal-control shelters
	Northern Power Systems 1 Northwind Road Moretown, VT 05660	Solar charge controller
	OEM Controls, Inc. 12 Control Drive Shelton, CT 06484	Transfer switch for emergency engine-generators
	Parker Hannifin Corp. Hose Products Division 30240 Lakeland Blvd Wickliffe, OH 44092	Hoses/fittings Lister engine
	RACOR Industries, Inc. 1215 8th Street Modesto, CA 95354	Fuel filter in daytank assembly
	Saft-Nife, Inc. 711 Industrial Blvd. Valdosta, GA 31601	12V and 24V battery chargers, NiCad batteries
	Siemens Solar Industries 4650 Adohr Lane P.O. Box 6032 Camarillo, CA 93011	Emergency solar panel
	Solarex Corporation 630 Solarex Court Frederick, MD 21701	Emergency solar panel

	Square D Company 1717 Centerpark Road Lincoln, NB 68512	Power distribution Panel (QQ 20-30MG150)
	Stimsonite Corporation 7542 Borth Natchez Avenue Niles, IL 60648	190mm lantern, 250mm lantern, 155mm lantern
78388	**Synchro-Start Products, Inc.** 8151 N. Ridgeway Avenue Skokie, IL 60076	Fuel stop solenoid on Lister engine
11532	**Teledyne Relays** Dept. EM 12525 Daphne Avenue Hawthorne, CA 90250	Relays in controllers
13419	**Tideland Signal Corporation** 4310 Directors Row Houston, TX 77092	155mm lantern, 300mm lantern, CG4P-120 lampchanger, FLAC 300 RACON
	Precision Multiple Controls 33 Greenwood Avenue Midland Park, NJ 07432	AC Daylight Controls
	Vega Industries Limited Heriot Drive Porirua, New Zealand	VRB-25 rotating beacon, directional (sector) lights

STANDARD EQUIPMENT WEIGHTS (in pounds)

	DESCRIPTION	UNIT WEIGHT	NO UNITS	WEIGHT
1.	Equipped Shelter:			5,200
	Cables/Raceways and Lights/Misc	500	---	
	Power Exit/Distr Pnl and Penetrator	200	---	
	Bare Shelter (10 x 16 x 9)	4,500	2	
2.	Engine System: 11K			3,650
	Engine (Dry)	1,410	2	
	Engine System: 6.5KW			3,380
	Engine (Dry)	1,275	2	
	Thimble	40	2	
	Muffler	75	2	
	Exhaust Piping System	100	2	
	Cooling Duct	75	2	
	Lifting Rail,Chain and Block/Trolley	250	1	
3.	Lighthouse Power Controller			122
	Controller CEVV-LPC-20032	72	1	
	Transfer Switch	50	1	
4.	Fuel System			370
	Daytank	270	1	
	Piping, Filters and Penetrator	100		
5.	Environmental Control Systems			935
	Intake Unit	475	1	
	Exhaust Unit	190	1	
	Intake Hood	65	1	
	Exhaust Hood	55	1	
	Back Draft and Hood	75	1	
	Temp CNTR and Mounting	75	1	
6.	Battery System: (24VDC)			625
	Battery Charger	65	1	
	Batteries HED-100	20	20	
	Battery Rack (2) Step	60	1	
	Mounting HDW	30	1	
	Distribution Panel	50	1	
7.	Fire Suppression System:			160
	Storage Tank and Mounting HDW	100	1	
	Control Panels and Detectors	30	2	
	TOTAL OUTFITTED (PP) SHELTER WEIGHT 10KW.		1	11,038
	TOTAL OUTFITTED (PP) SHELTER WEIGHT 6.5KW		1	10,768

STANDARD SIGNAL EQUIPMENT WEIGHTS (in pounds)

DESCRIPTION	UNIT WEIGHT	NO UNITS	WEIGHT
1. Equipped Shelter: (10 x 16 x 9)			5,300
Bare Shelter (10 x 16 x 9)	4,500	1	
Equipped Shelter: (8 x 10 x 9)			3,000
Bare Shelter (8 x 10 x 9)	2,200	-	
PWR ENTR/SIG. Exit and Penetrators.	300	-	
Cables/Raceways and Lights/Misc	500	-	
2. ACMS & Comms Link System			445
Cabinet/PWR Supply and Meters	275	-	
Radio Link	45	2	
ACMS Package	80	1	
3. Radio Beacon:			300
NX250	300	1	
NX1000	300	1	
NX4000	600	1	
4. Audio/Visual Signal Systems;			490
CG-1000 Power Supply	350	1	
Mounting HDW	30	2	
Controller (AVC)	80	1	
5. Battery System: (12VDC)			455
Battery Charger	75	1	
Batteries ED-240	30	10	
Mounting HDW	30	1	
Distribution Panel	50	1	
6. Environmental Control System:			60
Intake Unit	25	1	
Exhaust Unit	25	1	
Control Unit	10	1	
7. Fire Suppression System: 36 lb			140
36 lb Storage Tank and Mt HDW	100	1	
Fire Suppression System: 18 lb			115
18 lb Storage Tank and Mt HDW	75	1	
Control Panels and Detectors	20	2	
TOTAL LARGE (LP) SIGNAL SHELTER WEIGHT			7190
TOTAL SMALL (EP) SIGNAL SHELTER WEIGHT			4865

Operational Checkout Procedures for 120VAC Automated Lighthouses

A. INTRODUCTION

1. The following checkout procedure is offered as a guideline to assure an automated lighthouse is capable of operational status. The procedures are not intended to be complete (as in a maintenance checkout); they are intended to provide satisfactory evidence that the system operates as planned, i.e., the power, monitor, control and fail-safe functions respond as intended.

2. The checkout procedure consists of system checks for: (1) lighthouses with Aid Control-Monitor Systems (ACMS), and (2) non-monitored systems. The checks utilize the ACMS Master Unit (MU) display and various remote station equipment control panels.

B. ACMS MONITORED AND CONTROLLED SYSTEMS

1. Communications Link. The proper operation of the link equipment should be verified before proceeding with any other tests. Assuming that power is available to operate the link equipment, the link checkout procedure performs a check of the link system and provides a starting point for the remaining checkout procedures. The link check uses the Audio Visual Controller (AVC), Remote Unit (RU), microphone and MU.

2. AC Power System. The 120VAC power system checkout insures that the Lighthouse Power Controller (LPC) properly performs its basic function of engine exercise, primary and secondary start-up, and MU display response. This checkout assumes a four minute warm-up interval in the LPC.

3. Sound Signal System. The sound signal system (consisting of a main sound signal and a emergency sound signal) checkout insures that the main-to-emergency operational sequences work properly. It also insures proper operation of the fog detector (if installed), and MU display response.

4. Light Signal System. The light system typically consists of a single main light, either rotating, flashed or fixed, and an emergency light. The system checkout insures that the reset, failure transfer, and MU display functions operate properly. The check uses the AC distribution panel, the AVC, and the MU display.

5. Radiobeacon System. The radiobeacon system consists of a transmitter with dual exciter/keyer modules and dual power supplies. The system checkout insures reset, failure, and MU display functions operate properly.

C. UNMONITORED SYSTEMS

The signal and signal control systems for all Lighthouse Category I, II and III systems function the same way, whether monitored or not. To use the following system checks for unmonitored aids, just disregard steps related to outputs to the ACMS Remote Unit and control commands from the ACMS Master Unit.

Operational Checkout Procedures for 120VAC Automated Lighthouses (continued)

D. ACMS LINK CHECKOUT

1. ACMS incorporates a two-way voice circuit to enable technicians with the Remote Unit site (RU) to communicate with personnel at the Master Unit site (MU). Connect a microphone to the MICROPHONE jack on the front of Switching Unit 2A3.

2. Key the microphone. A Voice Request message is sent to the assigned MU. The yellow STANDBY lamp will illuminate. The operator at the MU site has the option of acknowledging or denying the voice request. Acknowledgment is signaled when the STANDBY lamp extinguishes and the green TALK lamp illuminates.

3. When the TALK lamp illuminates, key the microphone and talk.

4. When the RU receives a voice request initiated by the MU, an audible alarm sounds and the yellow STANDBY lamp lights up. Connect a microphone to the MICROPHONE jack on the front of Switching Unit 2A3.

5. Key the microphone. A Voice Acknowledgment message is sent to the MU which initiated the Voice Request.

6. After a short delay, a final message will be received by the MU. Then the yellow STANDBY lamp will go out and the green TALK lamp light up. This indicates the voice circuit has been established.

7. To send a voice message, key the microphone and talk into it.

8. To receive a response, release the microphone key.

9. The voice circuit is automatically terminated when neither microphone is keyed for a period of 60 seconds.

E. POWER SYSTEM CHECKOUT

1. If there have been any changes to the AC monitoring circuits, the Lighthouse Power Controller (LPC) must be run through the voltage/frequency calibration routine.

2. Make sure the all power is turned OFF to engines and to the LPC.

3. Turn ON DC Power circuit breaker for the LPC located on the 24VDC Power Distribution Panel.

4. Turn POWER toggle switch on LPC to ON.

5. Press POWER on LPC to apply power to controller and display status messages.

**Operational Checkout Procedures for 120VAC
Automated Lighthouses (continued)**

E. POWER SYSTEM CHECKOUT (cont)

6. Press FAIL/RESET to clear any failure status.

7. Press CRANK for engine #1 to start the primary engine-generator.

8. Call Master Unit (MU) via dial-telephone or cellular phone to confirm primary engine is "ON LINE".

9. Press EXERCISE on the LPC. The secondary engine-generator will start up and be placed "ON LINE" after an initial warm-up period (4-minutes).

10. Request remote interrogation. Confirm the secondary engine-generator is in the "EXERCISE" mode and then "ON LINE.

11. FAIL the primary engine-generator by applying a ground to TB1-2 on the LPC. This will simulate <u>low oil pressure</u> thus shutting down the primary engine-generator.

12. Request remote interrogation. Confirm that the primary engine-generator has failed.

13. Press FAIL/RESET to clear fail status.

14. Press EXERCISE to exercise the primary and allow it to take the load.

15. Request remote interrogation. Confirm that the primary engine-generator is "ON LINE".

16. Fail the secondary engine-generator by applying a ground to TB2-1 on the LPC. This will simulate <u>high oil temperature</u> thus shutting down the secondary engine-generator.

17. Return system to normal operation.

F. SOUND SIGNAL SYSTEM CHECKOUT

1. Place all sound signal circuit breakers on the AVC to the OFF position, wait 1 minute, then request an interrogation. This secures the entire sound system. Confirm sound signal registers a FAIL indication at the MU.

2. Place all sound signal circuit breakers on the AVC to the ON position and request an interrogation. This prepares the system to be remotely reset. Confirm the following reading:

SOUND SIGNAL STATUS- FAIL   EMERGENCY SOUND- ON

Operational Checkout Procedures for 120VAC Automated Lighthouses (continued)

F. SOUND SIGNAL SYSTEM CHECKOUT (cont)

3. At the main sound signal control panel insure that the power and horn circuit breakers are ON, coding switch to AUTO, master/slave switch to MASTER. Request a station reset from MU; wait 1 minute and request an interrogation. Confirm the following reading:

SOUND SIGNAL STATUS- NORM EMERGENCY SOUND- OFF

4. At 2TB6 within the AVC connect a lead between terminal #1 and Terminal #3, wait 1 minute, then request an interrogation. This simulates fog detector control of the sound signal. The sound signal is OFF. Confirm the following reading:

SOUND SIGNAL STATUS- NORM EMERGENCY SOUND- OFF

5. At 2TB6 within the AVC release the lead between terminals #1 and #3, then request an interrogation. This simulates a release of fog detector control and insures that the release caused the system to the main sound signal. Confirm the following reading:

SOUND SIGNAL STATUS- NORM EMERGENCY SOUND- OFF

6. Place the horn circuit breaker on the MASTER sound signal to the OFF position; wait 1 minute, then request an interrogation. This simulates a failure of the main sound signals and insures that the failure causes the emergency sound signal to turn ON. Confirm the following reading:

SOUND SIGNAL STATUS- FAIL EMERGENCY SOUND- ON

7. Place the horn circuit breaker on the MASTER sound signal to the ON position, press the sensor board reset switch on the AVC, and request an interrogation. This resets the main sound signal and returns the system to NORMAL operations. Confirm the following reading:

SOUND SIGNAL STATUS- NORM EMERGENCY SOUND- OFF

8. At the Power Distribution Panel, place circuit breaker #4 (AVC POWER) to the OFF position, wait 1 minute, then request an interrogation. This simulates a power failure and insures that the emergency sound signal turns ON. Confirm the following reading:

SOUND SIGNAL STATUS- FAIL EMERGENCY SOUND- ON

9. Place the above circuit breaker #4 back to the ON position, wait 2 minutes, then request an interrogation. This insures restoration of AC power to the sound signal and causes the system to reset to NORMAL operations. Confirm the following reading:

SOUND SIGNAL STATUS- NORM EMERGENCY SOUND- OFF

Operational Checkout Procedures for 120VAC Automated Lighthouses (continued)

G. LIGHT SIGNAL SYSTEM CHECKOUT

1. Place all light system circuit breakers in the AVC to the OFF position; this includes the Main Light, Ballast, Motor Drive, and Emergency Light breakers. This will secure the entire light system. Wait 1 minute, then request an interrogation. Confirm the following reading:

MAIN LIGHT STATUS- FAIL   EMERGENCY LIGHT- OFF

2. Place all above mentioned circuit breakers to the ON position; wait 1 minute, then request an interrogation. This prepares the light system to be remotely reset. Confirm the following reading:

MAIN LIGHT STATUS- FAIL   EMERGENCY LIGHT- ON

3. When the MU display in procedure 2 is verified, request a AVC Reset from the MU. This resets the light system from the MU and places it in an NORMAL mode of operation. Wait 1 minute, then request an interrogation. Confirm the following reading:

MAIN LIGHT STATUS- NORM   EMERGENCY LIGHT- OFF

4. At the AVC place the Main Light "LIGHT" circuit breaker to the OFF position. This will simulate a failure of the main light and insures that the emergency light turns ON. Wait 1 minute, then request an interrogation. Confirm the following reading:

MAIN LIGHT STATUS- FAIL   EMERGENCY LIGHT- ON

5. Place the above circuit breaker to the ON position, press the AVC's Sensor Board Reset switch once. This will manually reset the main light to the NORMAL mode of operation. Wait 1 minute, then request an interrogation. Confirm the following reading:

MAIN LIGHT STATUS- NORM   EMERGENCY LIGHT- OFF

6. At the AVC place the Main Light "MOTOR" circuit breaker in the OFF position. This will simulate a failure of the rotation motor for rotating beacons (does not apply to fixed or flashing lights). Wait 1 minute, then request an interrogation. Confirm the following reading:

MAIN LIGHT STATUS- FAIL   EMERGENCY LIGHT- ON

7. Place the above circuit breaker to the ON position, press the AVC's Sensor Board Reset switch once. This will manually reset the main light to the NORMAL mode of operation. Wait 1 minute, then request an interrogation. Confirm the following reading:

MAIN LIGHT STATUS- NORM   EMERGENCY LIGHT- OFF

Operational Checkout Procedures for 120VAC Automated Lighthouses (continued)

G. LIGHT SIGNAL SYSTEM CHECKOUT (cont)

8. At the Power Distribution Panel, place circuit breaker #4 (AVC POWER) to the OFF position, wait 1 minute, then request an interrogation. This simulates a power failure and insures that the emergency light turns ON. Confirm the following reading:

MAIN LIGHT STATUS- FAIL EMERGENCY LIGHT- ON

9. Place the above circuit breaker #4 back to the ON position, wait 2 minutes, then request an interrogation. This insures restoration of AC power to the light system and causes it to reset to NORMAL operations. Confirm the following reading:

MAIN LIGHT STATUS- NORM EMERGENCY LIGHT- OFF

H. RADIOBEACON SYSTEM CHECKOUT (DGPS radiobeacon not applicable)

1. Check the radiobeacon operational status as outlined in the preceding paragraphs to verify that the system is in the NORMAL mode and that the output power is normal. Any anomalies must be corrected.

2. Call MU via dial-up telephone or cellular and request a remote interrogation. Confirm the radionbeacon status display "Normal".

3. Fail Exciter "A" by setting its mode switch to "CW" and setting Exciter "B" mode switch to "BEACON". The transmitter shall be in the "Beacon" mode, the STANDBY lamp shall be ON and the NORMAL lamp shall turn OFF after 20 seconds indicating exciter changeover.

4. Request remote interrogation. Confirm that the radiobeacon display status is in the STANDBY mode.

5. Fail Exciter "B" by setting its mode switch to "MCW". Transmitter RF output shall turn off, the SHUTDOWN lamp shall turn ON after 20 seconds.

6. Request remote interrogation. Confirm that the radiobeacon status display is "shutdown".

7. Turn both mode switches to "BEACON".

8. Reset the system by momentarily switching the transmitter "OFF" and then "ON". This action can be initiated locally by using the main power switch or remotely by using "remote on/off" control. Transmitters that have been reset will always go to the selected "main" exciter/keyer combination.

Operating Checkout Procedures for 12VDC Solar Powered Lighthouse

A. INTRODUCTION

1. The following checkout procedure is offered as a guideline to assure a solar lighthouse is capable of operational status. The procedures are not intended to be complete (as in a maintenance checkout); they are intended to provide satisfactory evidence that the system operates as planned, i.e., the power, monitor, control and fail-safe functions respond as intended.

2. The checkout procedure consists of system checks for: (1) lighthouses with Low Energy Aid Control-Monitor systems (LEACMS), and (2) non-monitored systems. The checks utilize the ACMS Master Unit (MU) display and various remote station equipment control panels.

B. LEACMS MONITORED AND CONTROLLED SYSTEMS

1. Communications Link. The proper operation of the link equipment should be verified before proceeding with any other tests. Assuming that power is available to operate the link equipment, the link checkout procedure performs a check of the link system and provides a starting point for the remaining checkout procedures.

2. 12VDC Main Power System. The 12VDC main power system checkout insures that the main power system components properly perform their basic functions of power collection, distribution, charge control and MU display response.

3. Emergency Power System. The emergency power checkout insures that main to emergency power operational sequences work properly and produce the correct MU responses.

4. Signal Control System. The light system typically consists of a single main light, either rotating, flashed, or fixed, an emergency light, a main sound signal and emergency sound. The system checkout insures that the reset, failure transfer, and MU display functions operate properly.

C. UNMONITORED SYSTEMS

The signal and signal control systems for all Solar Category I, and II solar powered lighthouse systems function the same way, whether monitored or not. To use the following system checks for unmonitored aids, just disregard steps related to outputs to LEACMS Remote Unit and control commands from the ACMS Master Unit.

Operating Checkout Procedures for 12VDC Solar Powered Lighthouse

D. LEACMS LINK CHECKOUT

1. Equipment Turn-on. If the LEACMS Remote Unit (GCF-W-1221(D1)) has been previously initialized, simply turn switches 1A4S3 and 1A4S2 "ON". Then, PUSH the PBRESET for about one second. The green LED at position 07 lights and the red LED at position 13, A/V Reset, will light momentarily (about 03 seconds). The RU will now wait approximately one and a half minutes, poll the opto isolation I/O modules (optos) for current status, and then initiate a call to the MU.

2. If the GCF-W-1221(D1) has not been previously initialized, follow the steps to turn on and initialize the equipment in the LEACMS RU Technical Manual.

3. With the Burr-Brown TM-76 microterminal, perform a "LINK-TEST", which is within the maintenance routines of the Burr-Brown.

4. Request remote interrogation. Confirm that all remote operations are NORMAL.

E. 12VDC MAIN SOLAR POWER CHECKOUT

1. Ensure that all circuit breakers in the Solar Distribution Box (SDB) and the Solar Charge Controller (SCC) are in the ON position. Request remote interrogation. Confirm that all operations are NORMAL.

2. Check the solar array to confirm module cover glass is free of dirt, guano, etc. Check the solar panel mounting frame for any damage and confirm that the array is mounted at the correct angle and faces due South. Check the solar panel wiring for abrasions or damage by birds, etc. Replace if necessary.

3. Perform a "Diode Test". Cover one string of the solar array with a tarp or bungie cords. (A string is all panels terminated into one Local Terminal Box (LTB) at once.) Remove the fuse in the PV Combiner Box (PVCB) that corresponds to the covered string and install a load tester, in the 3000 AH/Solar setting, across the fuse terminals. Measure the voltage across the fuse terminals. If the voltage is equal to 0 volts, then the panels are good. If the reading is greater than 0, then one or more of the panels in the string is bad. To find it, install the fuse in the PVCB, disconnect all of the positive leads from the LTB that corresponds to the covered string, and install the load tester between first positive lead and any positive terminal. Measure the voltage across the load tester's alligator clips. Replace the panel if the reading is greater than 0 volts. Repeat this procedure for each panel in the string. Repeat "Diode Test" for each string.

Operating Checkout Procedures for 12VDC Solar Powered Lighthouse

E. 12VDC MAIN SOLAR POWER CHECKOUT (cont)

6. Upon completion of the test, return to normal operation.

7. In the Solar Charge Controller, switch circuit breaker #4 (the load) to the OFF position. Request remote interrogation. Confirm that the load has been transferred to emergency power, the emergency signals are on and the MU displays Emergency Light ON, Emergency Sound ON, Main Battery Low and Auxiliary Battery On-Line.

8. In the Solar Charge Controller, switch circuit breaker #4 to the ON position. Request remote interrogation. Confirm that power has been transferred back to the main battery and that the main signals are on.

Turn off LEACMS during the remaining procedures to prevent inadvertent keying of the radio link.

9. Measure the voltage of each cell in the main battery (the cells do not have to be disconnected) with circuit breakers CB1, CB2 and CB3 in the Solar Charge Controller ON (solar panels connected) and the load circuit breaker CB4 OFF. Voltages should be 2.30 to 2.50 per cell ± 0.02.

10. Disconnect the solar array and loads by turning off circuit breakers CB1, CB2, CB3 and CB4 in the Solar Charge Controller and wait at least 10 minutes. Measure the voltage of each cell. The voltages should be 2.05 to 2.14 per cell ± 0.02.

11. With solar panels still disconnected, turn on the load circuit breaker CB4 in the Charge Controller and cover the photoresistor so that the main light comes on. Measure the voltage of each cell. The voltage should be 1.96 to 2.13 per cell ± 0.02. Remove cover on the photoresistor.

12. Measure the specific gravity of each cell and record in the aid log. In addition, record the electrolyte temperature (as read on the hydrometer).

13. Check each cell for sediment buildup. Add distilled water to the cell to bring the electrolyte level to the HIGH mark on the cell jar.

14. Remove accumulation of dust or other contaminates from the cell covers and jars with a cloth dampened with clean potable water.

F. EMERGENCY BATTERY CHECKOUT

1. Measure the voltage of each cell in the emergency battery (the cells do not have to be disconnected) with circuit breakers in the Solar Distribution Box ON (solar panels connected). Voltages should be 1.45 to 1.55 per cell.

Operating Checkout Procedures for 12VDC Solar Powered Lighthouse

F. EMERGENCY BATTERY CHECKOUT (cont)

2. Measure specific gravity of each cell. Add distilled water to the cell to bring the electrolyte level to the HIGH mark on the cell jar.

3. Remove accumulation of dust or other contaminates from the cell covers and jars with a cloth dampened with clean potable water.

G. SIGNAL CONTROL SYSTEM CHECKOUT

1. Turn on power to LEACMS Remote Unit. Ensure that all system operations are performing normally. Request remote interrogation. Confirm that all system operations are normal.

2. Cover the main light photoresistor so that the light will come on. Request remote interrogation. Confirm that the main light is NORMAL.

3. Fail the main light by turning off the main light circuit breaker located on the SDB. Note that the main light lampchanger will continue to advance until power is restored or the last lampchanger position is reached.

4. Request remote interrogation. Confirm that main light is extinguished and that the emergency light is ON.

5. Return lampchanger to the #1 position and switch the main light circuit breaker to ON. Request an Audio/Visual Reset from the MU. Confirm that the main light is ON and the emergency light is OFF. Remove cover from photoresistor.

NOTE: An alternative method of turning the main light off for servicing purposes is by applying a ground to the SACII L1's CONTROL terminal TB1-5. This will turn off the main light without causing unwanted lampchanger advance.

6. Fail the main sound signal by turning off the main sound circuit breaker in the SDB. Request remote interrogation. Confirm that the main sound signal is OFF and that the emergency sound signal is ON.

7. Turn main sound signal circuit breaker to the ON position. Request an Audio/Visual Reset from the MU. Confirm that the main sound signal is ON and emergency OFF.

8. Return entire system to NORMAL status. Request interrogation to confirm.

5-00 219/ P.O. 35786